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Construction Details of Bridge Across Portland Harbor

The bridge now in construction across an arm of the harbor between Portland and South Portland, in Cumberland County, Maine, comprises two long approaches on the Portland side, each of reinforced-concrete beam-and-girder construction, a stretch of 700 ft. of reinforced-concrete cantilever-girder spans, 1,000 ft. of steel cantilever spans, with a middle rolling lift, and a length of 275 ft. of concrete beam-and-girder construction on the South Portland side. Its design was described in an earlier issue of *Engineering News*. There are, however, some points n the construction which are worthy of separate notice. There existed at the site an old highway bridge which paralleled and overlapped the new bridge from South Portland to the Portland bulkhead line, but which turned westward, away from the new bridge, from that point. On account of the heavy traffic it was necessary to maintain a crossing for vehicles, foot passengers and street cars across the harbor, though the interference of the new and old bridge lines precluded the possibility of using the entire old bridge. As a solution it was decided to tear down the Portland shore crossing of the old bridge and divert the traffic eastward along the waterfront street at the bulkhead line, at the same time building a new pile-bridge diversion—in the shape of a wide open letter V—which crossed the main harbor channel with a temporary swingbridge at the point of the V. The South Portland section of the old bridge—narrowed slightly on account of the encroachment of the new roadway—continued the temporary crossing to the south.

FIG. 1. VIEW ALONG PORTLAND HARBOR BRIDGE, LOOKING TOWARD SOUTH PORTLAND

Main bridge section in middle. Temporary bridge, with angle in plan to provide for drawbridge swing, approached from roadway alongside railway yard at left. Laying tracks on concrete-beam section in foreground. Steel-girder section next beyond under erection. South Portland approach in background

The view in Fig. 1 was taken from a high point at the Portland end of the new bridge. It shows the new bridge under construction on the right, with the temporary crossing at the left. The V diversion, it will be seen, was necessary in order to make space for the swing of the drawbridge. The temporary drawbridge is of the swingbridge type, mounted on a timber-pile center pier and providing two 70-ft. channels. The bridge, which was designed and built for this temporary service, is made up of two trusses, 21 ft. 4 in. c. to c. and extending 86 ft. on each side of the 4-ft. wide center-bearing girder. The timber floor is carried on floor-beams suspended below the posts. Each truss is 8 ft. deep and is self-supporting when the span is closed. When the draw is open the outstanding trusses are carried from a central tower by 1¾-in. rods extending down to a point about two-thirds of the way along the truss. Electric power is used for operation.

The concreting of the various widely distributed sections of the bridge is done from three central points, at each of which is located a mixing and conveying plant. Two of these plants (on the Portland side) are of the chuting type. The one on the South Portland side is the old-fashioned derrick-and-bucket method.

Plant No. 1 was located about midway of the State St. or north approach, at the foot of Tyng St. It comprised a one-yard Smith mixer located in a pit dug below the level of the street and overhead bins, which could be loaded directly from wagons coming down Tyng St. There was a 120-ft. steel tower of the Lakewood type from which the approach could be controlled from the north end to a point near the main bridge, where the other plant took up the work. The extent of the spouting was about 220 ft. from the base of the tower.

For the main Portland end of the bridge and for the west approach the concreting was done from a tower located near the junction of the approaches and main bridge. This equipment was in service at the same time as the north-approach equipment. The details were practically the same, except that the tower was 155 ft. high, though as it was located on the street some 42 ft. below the floor level of the bridge its total height was about the same. It could control some of the north approach, all of the west approach and practically all of the main concrete bridge, though some of the main bridge toward the middle had to be concreted from buggies pushed from delivery hoppers at the end of the extended chute.

It is stated by the contractor that in this work the limit of chuting was found to be at about a 30° angle with the horizontal. For a flatter angle the concrete had to be so wet as to make its integrity doubtful.

For some of the floor slabs of the steelwork a portable ¾-yd. Koehring mixer will be used, bringing in the material across the finished roadway of the bridge in wagons.

On the South Portland concrete section the amount of concrete to be laid was so small that it did not warrant the erection of a tower plant, so a 1-yd. Smith mixer has been mounted there. The material will be brought in over the old approach and the concrete delivered by a swinging derrick.

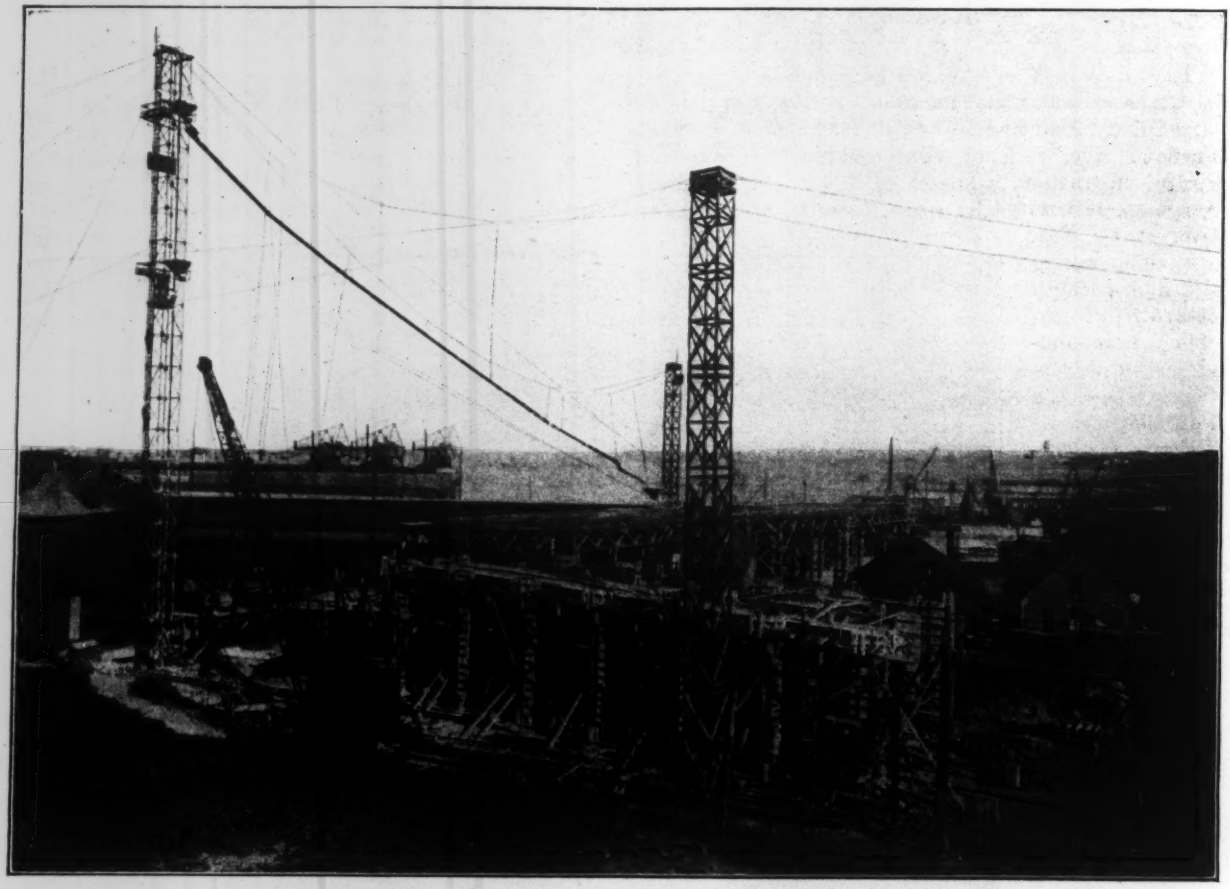


FIG. 2. CONCRETING TOWER AT PORTLAND END OF PORTLAND HARBOR BRIDGE

The view in Fig. 2 shows the second of the tower distributors in action at the juncture of the west approach at the right and the main bridge in the background. It will be noted that two secondary wooden towers had to be erected in order to carry the guy lines of the steel tower out of the way of the yard and also in order to carry the suspension wires for the chute in its extended position.

The aggregate used throughout was a graded sand and gravel obtained from a mixed bank at South Portland, where it is screened, washed and regraded before being carted by wagon to the various concreting plants at the bridge. In the whole job there will be about 30,000 cu.yd. of concrete, of which 12,000 cu.yd. is in the superstructure and 18,000 cu.yd. in the substructure. The steel reinforcement totals 729 tons.

Over 1,250,000 ft. of North Carolina pine was brought in by schooner to Portland to be used in the forms and centering for the bridge. Because of the varied skews and spans very little of the formwork could be standardized; but in spite of this some of the forms were used four or five times. The view in Fig. 3 shows the forms in place for the girders of the main bridge at the Portland end and illustrates the general type of form used. For centering under the cantilever girders over the railway track, wooden trusses (Fig. 4) were pretty generally used, supported by posts located where they could be between the numerous tracks of the terminal yards.

All this work, as well as all material transferred on the Portland end of the bridge, was carried on from a

FIG. 3. FORMWORK ON CONCRETE-GIRDER SECTION

Browning locomotive crane with a 65-ft. boom and a 35-ton rated capacity. On account of the great number of tracks available, this crane, which is provided with standard-gage trucks, could readily reach any part of the bridge. It may be noted in the foreground of the view in Fig. 2.

In concreting the main concrete span at the Portland end the pier bents were first completed to the base of the girder supports before the centering for the girders was placed. Then the cantilever girders were cast in one pouring from one overhang to the other and in groups of three transverse to the bridge. The corresponding three on the other side of the bridge were then cast. About two weeks after the main cantilever spans were all completed the intermediate or suspended spans were cast, all in one day. It required about 196 yd. of continuous pouring for one day's work on the largest of these girders.

Special Construction Details

The use of precast concrete railing sections and sidewalk brackets was commented on in the previous article. Such practice is fairly common, but it is unusual to ship concrete members of this sort by rail as far as from Boston to Portland, as was done in this case.

The setting of the curb forms is somewhat out of the ordinary. The floor slab for the bridge is cast level with the roadway, leaving the conduit space exposed. The conduits are then placed and covered with gravel fill on which is laid the steel-mesh reinforcing for the sidewalk. There is on hand on the job a series of blocked wooden stringers to which are attached at the proper location the steel corner-pieces for the curbing. This blocking is then set up along the edge where the curb would be and wired back to the reinforcement of the sidewalk. All that remains to be done, then, to cast the sidewalk is to pour it on the mesh as laid and to screen it off between the outer coping and the curb block as placed. When set, the wiring can be loosened and the curb blocking removed for future use.

Floating Caissons for River Piers

The river piers on which the steel spans of the bridge rest are all in deep water varying from 25 to 50 ft., with a 13-ft. maximum variation in tide. They are all skewed to meet the thread of the current and all have approximately the same general sections.

In general the piers are rectangular in plan and consist of a base of concrete, footing on timber piles, about 30x88 ft. in section and 11 ft. deep, with a prismatic upper part rising in much smaller section to just below mean low water. All of this part is mass concrete. Above this section the face of the pier is cut granite, with concrete backing, partly to provide a more artistic appearance, but mainly as a protection against the inter-tidal wear on the concrete, since it has been found in Portland harbor—which is salt water and frequently icebound—that concrete does not stand up well between tides.

There was no specified method of constructing these piers, the only provisions in the specifications being that the silt was to be dredged to a depth of at least 5 ft. below present bottom and that piles were to be driven to a resistance satisfactory to the engineer. It was also specified that the concrete foundation block might be deposited through water, provided the space was inclosed in tight sheeting and the method of placing the concrete was such as to insure dense, sound concrete. However, the contractors, after considering the matter, decided to construct

FIG. 4. PORTLAND END OF BRIDGE UNDER CONSTRUCTION

Note trussed centers for girders over railway tracks. State St. approach at right, Clark St. approach at left

seven of the ten piers by means of a floating caisson. This method was utilized and proved eminently successful.

In its elements the scheme was as follows: The pier site was first dredged to grade and the wooden piles driven on the close spacing (average 2½ ft.) required. The number of these piles per pier varied from 170 to 370. By means of a floating saw—with the usual circular-saw equipment of piledriver leads with a vertical shaft between them carrying a horizontally disposed circular saw at its lower end—the piles were cut off with great rapidity. Meanwhile on shore had been constructed a concrete caisson or open box, which was so built as to permit the erection on it of wooden sides. This box was floated

out to the pier site and concrete deposited inside of it in the open. As the concrete was deposited the box sank until it found a level bearing on the piles. It was then carefully adjusted to its proper location and the concrete carried up high enough to insure its being fixed on the piles. The masonry was then carried up to above high water, after which the wooden sides were removed and the pier completed.

Fig. 5 shows a sketch of the base of the concrete box. These boxes varied in size, but the dimensions of the largest were as follows: Length, 88 ft. 4 in.; width,

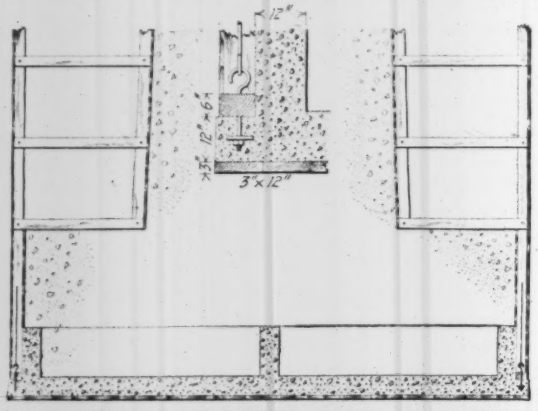
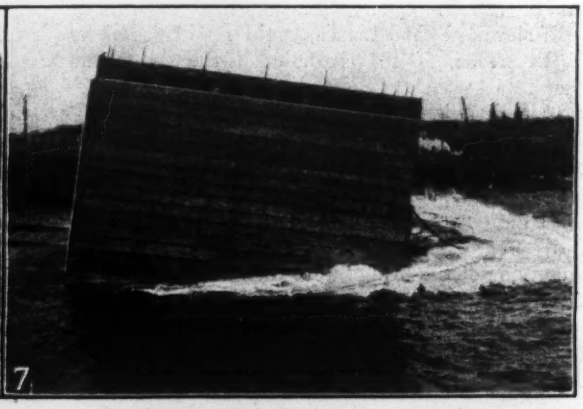


FIG. 5. SKETCH OF LOWER PART OF CONCRETE CAISSON FOR PIERS OF PORTLAND BRIDGE

32 ft. 8 in.; height, 4 ft. 6 in. The concrete section was cast on a 3-in. solid wood flooring attached to the concrete floor. The box itself was made up of 12-in. bottom and sides and interior walls. The outside of the bottom was provided with a 12-in. lip, into which were cast hook bolts as shown in the detail in Fig. 5. While still on the ways the studding for the forms for the lower part of the pier was attached to the hook bolts in the manner shown and those sides built up to a height sufficient to insure the floating of the box when it was launched. These sides were then calked so as to make the structure water-tight.

After launching (Fig. 7 is a view of the launching of one of these caissons) it was towed to place and the concrete work started. By careful manipulation of the filling of the concrete in the cells the whole caisson was sunk uniformly at a rate of about 2 ft. of sinking per 1 ft. of concrete total filling, the concrete being continued up into the forms above. When the whole box had its first even bearing on the prepared pile bed, the sluiceways in the sides of the forms were opened (Fig. 8) and the box allowed to take a firm bearing on the pile bed.

Inasmuch as this operation occurred some days after the pouring of the concrete, the wetting was not at all harmful. Only enough water was allowed to enter the forms to insure the stability of the pier on the bed. Then the concreting was continued up inside the forms in the dry, the outer forms serving as a coffer-dam. As soon as the concrete got above the water line the hook bolts were unbolted at the top and eased off, thus allowing the whole outer framework to be taken down to be used on another caisson under construction, the rest of the pier being carried up uniformly in open air, using the granite facing blocks as forms, inside which the concrete was placed. After the pier had taken its bearing, sand was dumped overboard alongside, it being hoped and expected that the sand would tail under the pier and fill up the short distance between the pile tops and the dredged foundation. The foundations are finally protected by a large amount of riprap deposited for a distance of 18 ft. on all sides of the pier.



FIGS. 6 TO 8. VIEWS OF CONCRETE CAISSONS USED IN BUILDING PIERS OF PORTLAND BRIDGE

Fig. 6—Concrete base on ways. Fig. 7—Launching a caisson. Fig. 8—Flooding a caisson in place

The bridge is being built for Cumberland County, Maine, under the direction of J. R. Worcester & Co., of Boston, Mass., as Engineer, with E. E. Pettee, of that firm, as Resident Engineer. The substructure contract was held by Holbrook, Cabot & Rollins, Inc., of Boston, with Luke S. White as Superintendent, and the superstructure contract by T. Stuart & Son Co., of Newton, Mass., with Albert T. Stuart, of the firm, as Superintendent. The structural-steel spans, including the Scherzer rolling-lift, are being built by the Phœnix Bridge Co.

Construction Progress on the Twin Peaks Tunnel

By A. J. Cleary*

SYNOPSIS—Methods used and progress made on long passenger tunnel on line of Market St. in San Francisco.

The principal features of the design of the Twin Peaks Tunnel were fully described in *Engineering News* of Feb. 20, 1915. The project is the largest thus far undertaken in any city for the extension of a street-railway system. The length of the tunnel is 12,000 ft., the width 25 ft. in the clear and the clear height above top of rail 15 ft. On its completion over 10,000 acres of very desirable residential territory, now isolated by reason of inadequate street-railway facilities, will be brought into direct communication with the downtown district.

On Nov. 12, 1914, a contract for the construction of the tunnel was awarded to Robert Storrie & Co. for the estimated sum of $3,372,000. Work was begun on both ends simultaneously on Nov. 30, 1914.

Up to the middle of October, 2,000 lin.ft. had been excavated westerly from the east portal and 1,860 lin.ft. of concrete tunnel lining had been poured. A short distance from the portal a large underground station has been provided for the accommodation of passengers transferring from subway to surface cars, and vice versa.

Excavation for the first 1,300 ft. of tunnel and for the underground station was performed in open cut with steam shovels. A few hundred feet from the portal the cut was so deep that it had to be taken out in two lifts. One shovel first excavated about 12 ft., loading into auto trucks on the bank above the excavation; behind this a second steam shovel completed the cut to the required depth, loading into auto trucks which followed up the steam shovel through the cut.

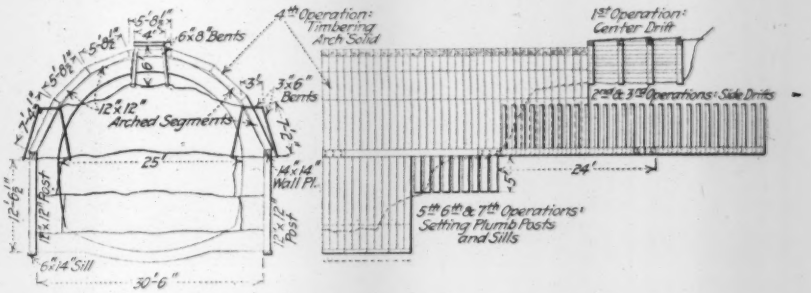


FIG. 2. TWIN PEAKS TUNNEL, EXCAVATION AND TIMBERING

Most of the material through which the excavation was made stood without lagging, but near the corner of 18th

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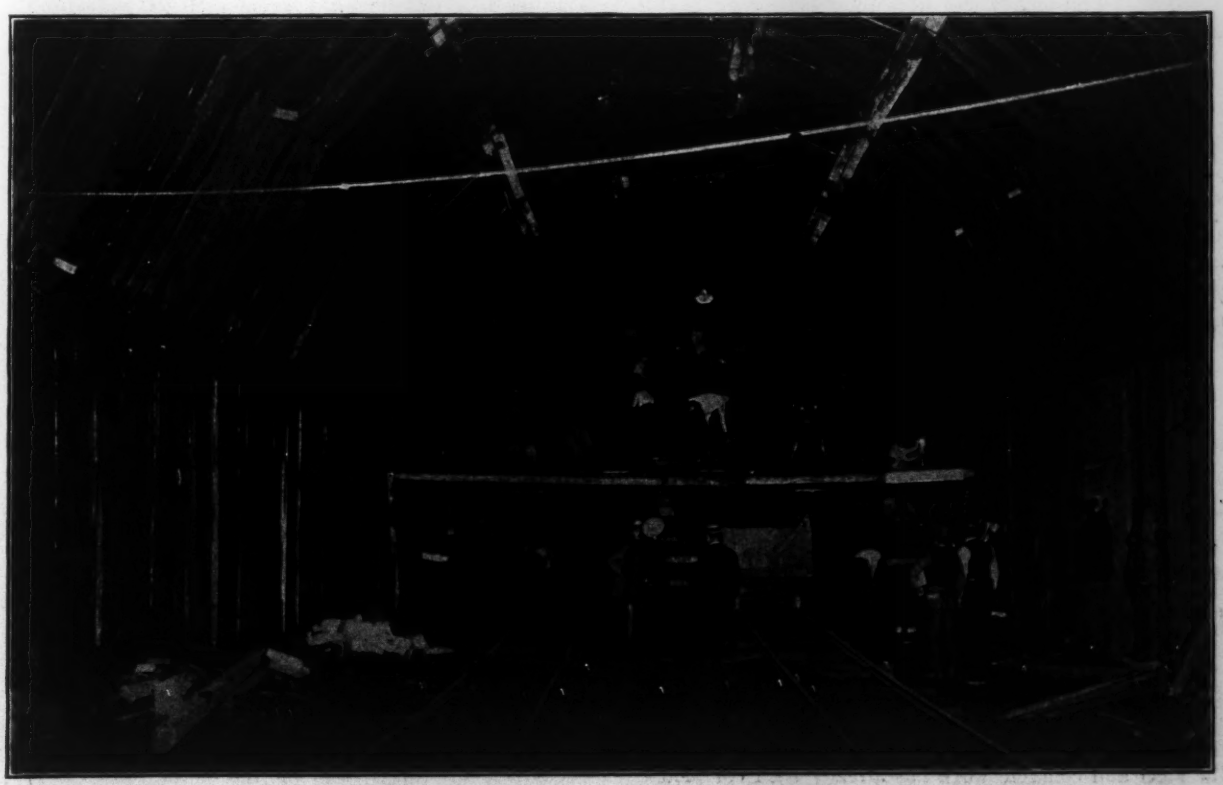


FIG. 1. TIMBERED TUNNEL EXCAVATION IN MAIN SECTION OF TWIN PEAKS TUNNEL

FIG. 4. TWIN TUNNEL FORMS IN OPEN CUT

and Hattie St. a deep fill extended across the line of the work. In this location it was necessary to drive 50-ft. sheeting on each side before excavation and brace across the trench with 12x12 spreaders.

The 18th St. car tracks of the United Railroads had to be carried across this cut without interrupting service. Piles were driven at 4-ft. centers along the sides of the proposed excavation. These were then capped by 12x12 timbers and 14x14 beams placed upon the caps to form

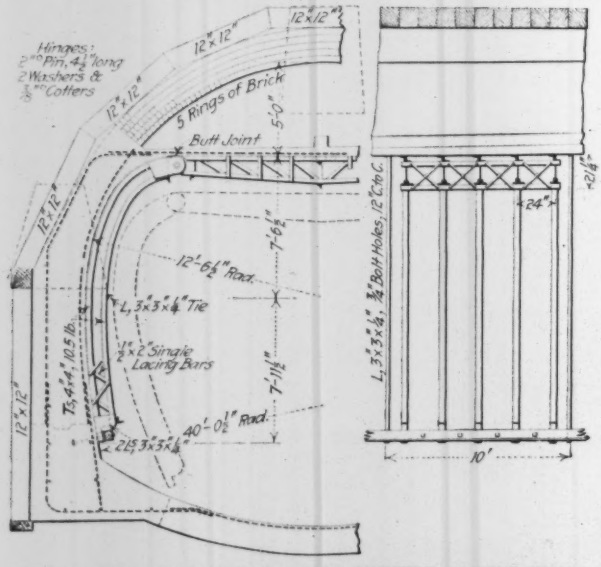


FIG. 3. COLLAPSING FORM FOR TUNNEL CONCRETING

a solid decking under railway and street. Girders were placed on top of the deck under each of the four rails.

The Eureka Valley station is a steel-beam structure, with 300-ft. platforms to accommodate four-car trains. The steel and concrete work has already been completed and the forms have been removed.

Between this station and the portal is a curve with a radius of 716.78 ft. Forms for the curve were built in 8-ft. chords, of 6x⅞-in. matched lumber with 2x6-in. vertical ribs. When the concrete had set and the forms were stripped the inner surface was entirely satisfactory.

Concrete Work with Hydrated Lime

The use as a waterproofing agent of 8 lb. hydrate of lime to every 100 lb. cement gave to the finished concrete a smooth, dense surface, so that little plastering was required.

The concrete at the east end is mixed in a 1-yd. mixer. Niles gravel, Niles sand and beach sand are the aggregate. Concreting has been very rapid. An average 8-hr. run is over 360 cu.yd. Considering that the concrete has to be wheeled for several hundred feet in buggies, the performance is a creditable one.

At the west end 1,650 lin.ft. of excavation and over 750 lin.ft. of concrete lining had been completed up to Oct. 16. Over half of the work so far completed at the westerly end has been done in open cut. Concrete is deposited through a shaft leading to the horizontal ventilating chamber immediately above the tunnel. It is then wheeled through this chamber to the headings and packed by hand in the forms.

Tunneling and Timbering

The method of timbering is shown in Fig. 2. Crown and wall-plate drifts are first driven and timbered. The earth between the drifts is then stoped out and 12x12-in. segmental arch timbers are set on 14x14-in. wall-plates, to form a close lining. Next, 12x12-in. plumb posts are placed along the sides, and finally the core is removed.

The material at the west end is a heavy packed sand and it is therefore necessary to place a solid lining.

An ingenious device has been erected by the contractor for removing the forms from the top of the tunnel after the concrete has been poured. This consists of a double

A-frame, cross-braced, at the top of which is a hinged support, which can be pressed against the roof forms and held horizontal by a prop while the forms are being pulled loose. The hinged support is then slowly brought to an inclined position and the forms allowed to slide down the A-frame. This has proved very efficient in safeguarding the men working beneath.

Excavation for the Laguna Honda station is 60% complete. The floor of this structure is only 62 ft. below the ground surface, so it was deemed most economical to excavate for the entire station from the surface in open cut. The material at this location is a well-compacted sand. Piles were driven by jet along the sides of the cut, to hold the banks in place. It is probable that the construction of the tunnel will be advanced in both directions from Laguna Honda station.

On the surface, directly above the station, a reinforced-concrete building 100 ft. long will be erected to serve as a surface station. Six 50-passenger elevators will operate between the underground and surface stations. As soon as the excavation is to grade, the steel and concrete in the station structure will be placed and the elevator shafts completed, in order that they may be used during construction as service shafts for the tunnel work.

Plans call for the construction of a ventilating shaft west of the center of the tunnel. This has been sunk to a depth of 30 ft., and when complete will probably also be used as a temporary construction shaft.

Funds for the tunnel construction are being provided by district assessment. The majority of the assessments are being paid in ten annual installments, with interest on deferred payments at the rate of 7%.

The tunnel is being constructed by Robert Storrie & Co., under the direction of M. M. O'Shaughnessy, City Engineer. Roy Hackley is engineer for the contractors.

Alleys in the City Street Plan

Should the street plan of a city include alleys? If so, why? These were two of a number of questions discussed by Charles B. Ball, Chief Sanitary Inspector of Chicago, in a paper entitled "The Alley Problem," read before the fourth National Conference on Housing in America, recently held at Minneapolis, Minn. Some extracts from the paper follow:

An alley may be defined as a minor public thoroughfare, not exceeding 20 ft. in width, extending through a block, in order to afford access, light and ventilation to the rear of the premises which abut upon it, as well as a suitable location for the public-service mains.

Three basic considerations in regard to alleys are: (1) Every alley must be dedicated to public use to permit the city to pave, clean, light and police these spaces. (2) Every alley must extend through the block from street to street. (3) Every alley must have a uniform width of not less than 16 ft.

Alleys exist in more than two-thirds of the cities of the United States, and, with two or three exceptions, are still laid out in additions to these cities. The great example of their nonexistence is the City of New York, where they are intentionally absent. I am unaware of any recently planned cities in which alleys have not been provided, although doubtless there are a few.

It is notable that in those American cities which show most careful consideration of the principles of city planning, such as Washington, Zion City, Savannah, Ga., and Vandergrift, Penn., alleys have been provided.

Vandergrift, Penn., laid out by Frederick Law Olmsted in 1895, is an excellent example of thoroughness in designing a small city. The street lines conform to the surface contours, and alleys 15 to 20 ft. wide are provided in each block.

The self-evident advantage of alleys is that they afford facility of access to the rear of premises for the supplying of goods—fuel, ice, milk, groceries, etc.—as well as for the removal of waste materials, such as garbage, ashes, rubbish and the like.

Attention has been directed for a year or two past to the tremendous distance traveled by the delivery wagon in making its ordinary deliveries, as well as to the waste of effort in the collection of household refuse where alleys are not available. It should be observed that the services referred to can be performed with a saving of 50% in distance traveled where alleys exist, as contrasted with blocks in which the service must be performed by street access only.

In addition to the marked saving of distance, as well as the convenience effected by alley access, it must be granted that the natural and desirable place of entrance of all those who perform services of this nature—for example, the iceman—is at the rear of the building rather than at the front.

One of the advantages of an alley system, hitherto little realized, is the convenience and speed with which fire-fighting apparatus may be brought through it into use.

Another advantage of alleys is that they afford more convenient access for the storage of vehicles on the rear of the lot. The man who has a small business, requiring only a single delivery wagon, would much prefer to keep that wagon, whether it be horse or motor propelled, at the rear of his lot. The convenience of the user of an automobile is greatly enhanced by being able to store it on his own premises instead of at a public garage.

No one can question that the day is near at hand when automobile storage on every third lot will be deemed a necessity; hence the argument in favor of providing the alley for this use is much more powerful than it would at first appear.

The use of the alley space for sewers, water mains, gas mains, ducts and wires for telephone, telegraph, lighting and power services has long been recognized by engineers.

In addition to the valid arguments already set forth to show why alleys are needed, the principal reason for their existence is still to be urged. An alley through the center of every city block is required because by this means alone is it possible to assure for the future a sufficiency of light and air in the middle of the block.

Railway Accidents in Germany in 1914 have been compiled and analyzed by the Association of German Street and Interurban Lines. This association embraces 178 lines, which during the year operated 750,000,000 car-km. (460,027,460 car-mi.) and carried 2,750,000,000 passengers. Accidents averaged one of a serious or fatal nature for 349,103 mi. operated. In Aix-la-Chapelle, which has the largest interurban system in Germany, the average was one accident for 402,166 mi. The fact that more pedestrians were injured or killed than passengers was established as usual. The association, taking an average for the 15 yr. from 1899 to 1914, states that 31.81% of the passengers injured suffered accidents through carelessness while boarding or leaving cars. Of the pedestrians injured, it reports that 54.46% were careless in crossing or walking along car tracks.

Torpedo-Boat Berth at the Charleston Navy Yard

The United States Government is building a torpedo-boat berth of reinforced concrete at the navy yard at Charleston, S. C., which involves some notable details in both design and construction.

The Charleston yard, stretching a mile along the west bank of the Cooper River, 7 mi. above its mouth, is used as the home port of the reserve torpedo flotilla, and for this purpose needs extensive berthing space for torpedo boats. Hitherto timber pile-and-deck piers perpendicular to the stream, and one L-shaped pier projecting from the shore for about 200 ft., and thence extending downstream parallel to the shore, have been used for this purpose. The L-shaped pier being in bad condition, it was decided to replace it by a permanent structure.

The design adopted for the permanent berth (shown in Fig. 1 by a general plan and several sections) was in part determined by the fact that the river-bank front of the yard had no permanent wall or wharf. The berth structure therefore was designed to include a shore wharf or quaywall along the bulkhead line of the river, a causeway running 360 ft. out into the stream at an angle of 69 deg. from the quaywall, inclining downstream, and an outer pier parallel to the quaywall. The substructures are all of open construction, so that the current of the river is not obstructed or diverted. Boats enter the basin between the shore wharf and outer pier parallel to the line of the stream, and it should therefore be easy to dock them at all stages of the tide.

The structure was designed by the Bureau of Yards and Docks, United States Navy Department, and is being built by the Snare & Triest Co., New York, the lowest bidder. The contract price for the entire work is $296,964.26.

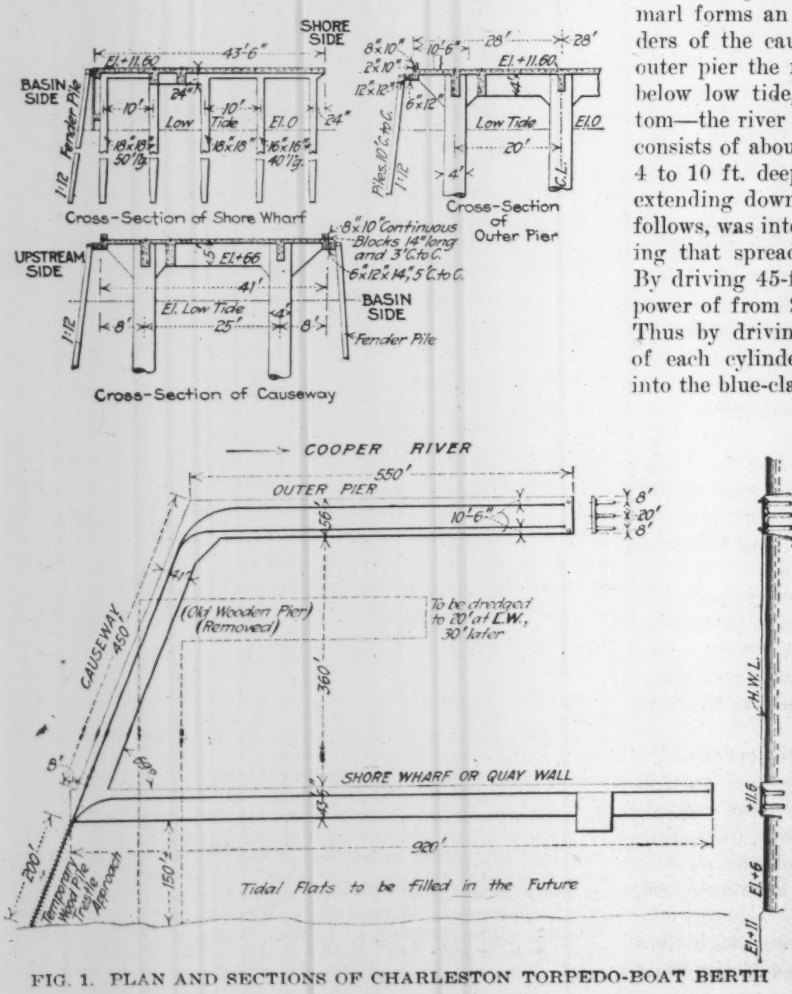


FIG. 1. PLAN AND SECTIONS OF CHARLESTON TORPEDO-BOAT BERTH

Reinforced-Concrete Structure

Two radically different types of structure are used in the berth. The quaywall consists of a concrete deck supported on concrete piles 10 ft. c. to c. each way. The causeway and the outer pier are carried on 4-ft. diameter concrete cylinders spaced 20x25 ft. for the causeway and 20x20 ft. for the outer pier. These cylinders are founded from 35 to 45 ft. below low-water level, resting either on marl or on wooden piles driven in a thick stratum of blue clay. The cylinder foundations are a vital feature of the whole structure.

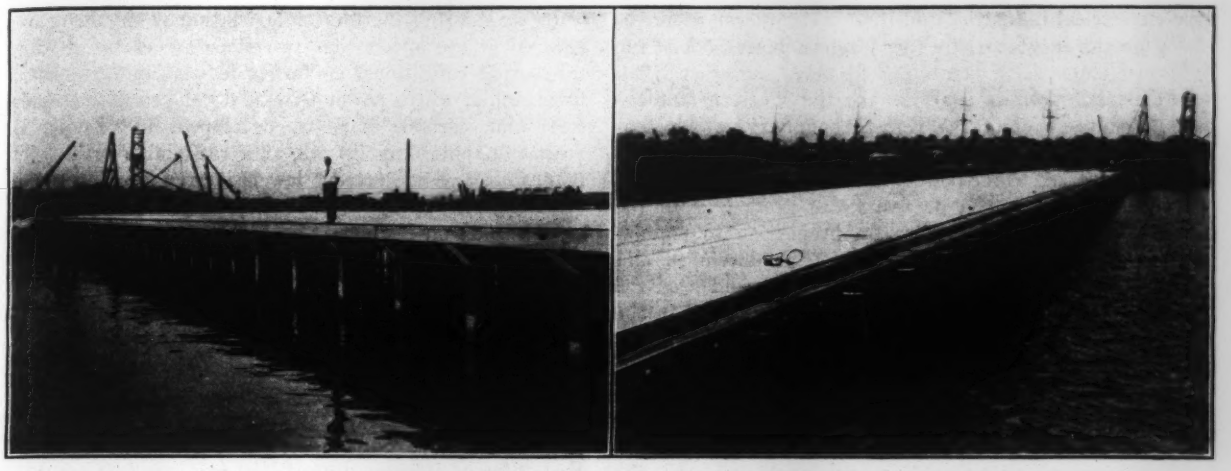
Both in driving the concrete piles and in building the cylinder piers much originality and resource were called for. The methods by which these parts of the work were carried through successfully will be described later.

Foundation Conditions

Marl underlies the quaywall at moderate depth, but this stratum dips rapidly toward the middle of the river. The marl forms an excellent foundation, but only five cylinders of the causeway rest directly upon it. Under the outer pier the marl lies at a depth of from 50 to 96 ft. below low tide, or about 18 to 64 ft. below river bottom—the river here being about 32 ft. deep. The bottom consists of about 3 ft. of soft mud, below this white sand 4 to 10 ft. deep, and below this a bed of stiff blue clay extending down to the marl. A test, described in what follows, was interpreted as showing the clay to be so yielding that spread footings could not be depended upon. By driving 45-ft. piles into the clay, however, a bearing power of from 20 to 25 tons per pile could be developed. Thus by driving a group of seven piles in the footing of each cylinder, and by building the cylinders 4 ft. into the blue-clay strata, the required foundation capacity was obtained, together with full protection against injury by scour or by attack of teredo.

A bearing test of the clay was made by a board of officers while the contract work was in progress and before the adoption of the final plans.

At a point where the marl was about 75 ft. below low tide a steel cofferdam cylinder 8 ft. in diameter was driven down by a steam hammer so that its cutting edge was embedded 4 ft. in the clay. The ground inside the cylinder was carefully leveled 6 in. above the cutting edge, and a grillage of 12x12 timbers, measuring 5 ft. square and 2 ft. thick, was placed on it. Nine concrete piles were then lowered until their points rested on this platform, making a total load of about 80 tons, or a little over 3 tons per square foot. Accurate levels were taken



FIGS. 2 AND 3. QUAYWALL OF CHARLESTON TORPEDO-BOAT BERTH
Fig. 2—Land side, to be filled. Fig. 3—Berth side, with fender piles

during all stages of the loading. As a result of the test it was considered inadvisable to rest the piers directly on the clay. It was specified that piles should be driven to a penetration of ½ in. per blow of a No. 1 Vulcan steam hammer having a 5000-lb. ram, falling 42 in.; but if this minimum penetration was not attained with 45-ft. piles, the piles were to be driven so that their tops would be embedded from 6 to 30 in. in the footing concrete of the cylinders some 3 or 4 ft. below the surface of the clay, where they would be protected from scour and teredo risk.

Deck Construction

The deck slab of the structure is carried by reinforced-concrete girder-and-joist construction spanning between the piles or the cylinders. In the causeway and outer pier the long spans require the girders carrying the railway tracks to be exceedingly heavy (20 in. wide by 5 ft. deep). These girders, the main transverse girders between columns, and the 9-in. deck slab make a total weight of about 140 tons per panel, which had to be carried by the forms and form supports during concreting. Special arrangements were required to take care of this load.

At present the quaywall has been completed and accepted and work on the causeway and outer pier is in progress and is about 40 per cent. completed. It is estimated that the entire structure will be completed in January, 1916.

No Federal Curb on Western Power Development*

By O. C. Merrill†

Eight years of close association with the water-power questions of the Western states have convinced me that the most fruitful cause of difference of opinion on a proper public policy of water-power development is misunderstanding of the actual conditions that exist.

The statement is frequently made that while there is 60,000,000 water horsepower in the United States, but 6,000,000 has yet been developed; and that all that would be necessary to bring about the substitution of water-power for steam and to check the appalling waste of coal is adequate Federal legislation.

Whether there is in fact 60,000,000 water horsepower in the United States no man knows. However, there are, particularly in the West, large amounts of undeveloped water-power. The estimated development of 6,000,000 hp. is correct if the previous rate of increase has been maintained since the last census. Of this amount about one-third is used directly in manufacturing; the remaining 4,000,000 hp. is used in the generation of electric power.

The steam-power development of the United States is about 28,000,000 hp., of which 18,000,000 is used directly in manufacture and 10,000,000 in the generation of electric power. But it by no means follows that if the public domain and the navigable rivers were thrown wide open to private exploitation water-power would or could entirely displace steam power.

Under prevailing practice in hydro-electric systems, even if abundant water-power were available within economical transmission distance from all our markets, and all our industries could be served with electric power, a reserve of not less than 12,000,000 steam power would still be required. But the water-power is not so available. It is absurd to assume that the millions of undeveloped water-power in Oregon and Washington can yet displace other millions of steam power in New York and Pennsylvania. The water-powers of western Pennsylvania and of northern New York, though free from Federal interference, cannot under present conditions be developed and transmitted to compete with steam power in the coal fields of Pennsylvania or at tidewater in the city of New York.

Eastern and Western Developments

The statement is made again and again that although there is urgent need for more power its development is stagnant in the Western states. The demand is made that the Federal Government relinquish its control over the power sites on its lands in order that development may proceed in the West as it has in the East under the stimulus of private ownership or state administration.

It would be only natural to expect that the longer established, more thickly settled Eastern states, engaged so extensively in manufacturing, should have developed

*Extracts from an address before the Western States Water Power Conference, Portland, Ore., Sept. 21.

†Chief Engineer, United States Department of Agriculture, Forest Service.

their electrical industries and their water-power resources to a greater degree than the Western states. Yet the Western states have accomplished more in 20 yr. than the Eastern states in 100 yr. In the Western states—the 11 states west of the Kansas boundary, which contain practically all of the remaining public land—the development of water-power has increased in the last 10 yr. alone by 450%, or five times as fast as in the Eastern states. Furthermore, in proportion to population, 4½ times as much water-power is developed and used in the Western states as in the remainder of the United States, and nearly three times as much as in the Eastern states. These figures are from this year's report of the United States census and are not subject to controversy.

Surplus of Western Power

The power plants of public-utility corporations in the State of California have a capacity of 1,000,000 hp. The sum of the maximum loads carried by the individual plants in 1914 was a little over 700,000 hp. The sum of the simultaneous peaks on the several systems probably did not exceed 600,000 hp. Of course, a certain amount of reserve for emergency and to anticipate extensions of market is necessary; but if we should allow for even a 50% reserve there would still be left a surplus of 100,000 hp. The State of California needs more users, not more power. A similar situation exists in Oregon and Washington and other Western states.

Another common statement is that under existing laws no development is being made or can be made on the public land.

Of the 1,800,000 hp. of developed water-power in the Western states 50% is in plants constructed in whole or in part on the National Forests and operated under permit from the Department of Agriculture. In addition, some 200,000 hp. is in process of construction and over 1,000,000 hp. more is under permit for future construction. If we add the plants which are occupying public land outside of the National Forests we should find that considerably more than one-half of the developed water-power of the Western states is being operated on the public lands under permit from the Federal Government.

This is not merely past history which recent conditions are changing. The Pacific Light and Power Corporation recently completed in California two power plants with an aggregate installation of 94,000 hp. as the initial step in an ultimate development of 250,000 hp., all of which will be on National Forest land and is now under permit. The Great Western Power Co. in the same state has permits for development aggregating 300,000 hp. on the Feather River and is making development as fast as the additional power can be disposed of. The Nevada-California Power Co. has four plants in operation on the National Forest, will complete a fifth this season and will begin a sixth next year. The Portland Railway, Light and Power Co. is operating a plant in the Oregon Forest and has permits for 40,000 hp. more which it proposes to develop as soon as use can be found for the power. Power sites of nearly 100,000 hp. on the Baker and Skagit Rivers in Washington are under permit to the Puget Sound Traction, Light and Power Co. to be developed when the existing surplus is disposed of.

In considering matters of legislation it should be recognized at the outset that two steps are essential—first, to provide conditions, as far as legislation can provide them, under which power may be developed at reasonable cost, and, second, when so developed, to provide the means for obtaining its sale at a reasonable price. The main defect of the present law is its apparent uncertainty of tenure. Although it is very doubtful if any action not justified on its merits could be sustained before the courts; although in the 14 years that the law has been in existence no attempt has ever been made to dispossess any occupant of the public lands or to stop the operation of any power plant, but merely to require compliance with the law, or to secure its interpretation by the courts; and although for many years the Federal departments have administered the law as though the power to revoke a permit save for just cause did not exist, yet there is little doubt that rates of interest and of discount are less favorable under the present law than could be secured under a different law.

The promoter desires to obtain title in order that he may have the potential value of the power site as property security for his financial transactions. This might be well enough in a bona-fide effort toward development; but the history of public-land grants forbids the belief that power sites would not be held more often for speculation than for development.

But even this is not the most serious result which would follow. The lands thus secured would increase enormously in value, and on this increased value, even under the most stringent rate regulation, the public would be required to pay interest and profits forever. Nothing can prevent this except the retention of the sites in public ownership, and no other course should be considered for a moment.

Leasing System Is Sufficient

All the protection that capital needs, all the capital that development requires can be obtained under a proper leasing system. All leases should be for a fixed term, probably not less than 50 years, and should be renewable to the holder upon expiration except only in the event that the Federal Government, the state or a municipality should wish to take over the properties. If so taken over, the lessee should be paid back his investment, less depreciation paid out of earnings and sinking funds accruing from earnings. The leases should be unalterable for their term, should contain every condition binding upon the lessee, and after investment has been made should be subject to cancellation only upon failure to comply with the express terms of the lease and by action instituted in appropriate courts, and even then only when the breach is of such a nature that it cannot be remedied by an action to compel specific performance. It is advisable to charge a minimum rental in all cases to cover administrative costs. It should be established as a general principle that no additional rental should be charged which would increase prices to consumers or reduce earnings of the utility below an adequate return.

Rate and service regulation has an important bearing on the question of securing cheap capital for power development. The states have the powers of regulation, and most of them are exercising it. Duplication by the Federal Government would be both unnecessary and unwise. Only for clearly emergency cases, where a state

had not provided itself with the means of regulation, would I reserve a right of action under a Federal lease.

It has been said that there is an irreconcilable conflict between the Nation and the States because the former claims to own the land and the latter claims to own the water, while power cannot be developed without the use of both. As far as the National Forests are concerned, the Department of Agriculture has solved the matter with mutual satisfaction. In California and Oregon all matters affecting power development are handled by co-operative and concurrent action. The Department would be glad to take similar action in any other state.

Scheme to Relieve Congestion at Busy Street Intersection

The great and increasing traffic congestion in cities has raised a municipal problem of vast importance, to arrive at a partial solution of which the Municipal Art Society of New York City opened a contest[1] and offered prizes for plans for the intersection of a street and an avenue. About 200 contestants entered, submitting plans in which were considered the elements of efficiency, economy and architectural beauty. The first prize was won by J. Floyd Yewell, of Peekskill, N. Y., whose design is shown herewith.

By this scheme automobiles and all horse-drawn vehicles cross the avenue on an underground level. The lower level is used, also, by the electric street cars, but these have a separate entrance and are in no way interfered with by other kinds of vehicle. For those persons desiring to enter the street cars, safety islands are placed at the entrance to the subway. By providing separate entrances for electric street cars and for automobiles, carriages, wagons, etc., space is gained for traffic which, coming from east or west on the cross street, intends to turn north or south into the avenue, as well as for those vehicles which, coming from north or south, intend to go east or west.

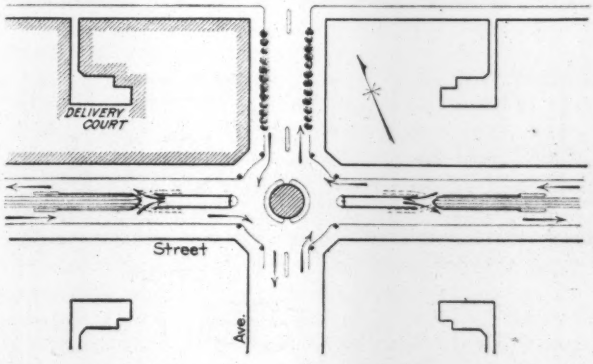
Avenue traffic is on the surface and all turning is rotary. At each crossing, in the very center of the avenue, safety islands are provided for pedestrians. Courts for the convenience of delivery wagons are provided, as shown in the plan. These courts, which are intended to relieve traffic on the main thoroughfares, have entrance on side streets.

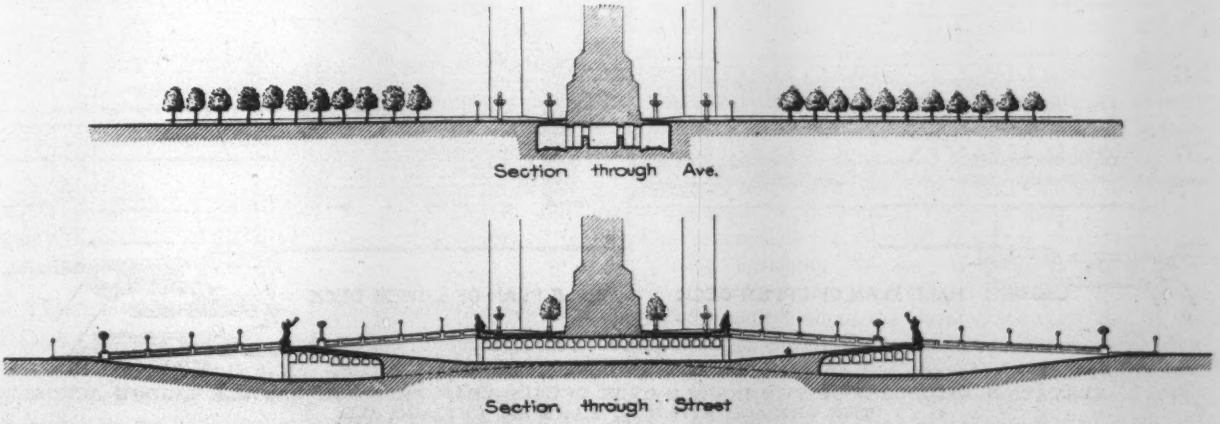
Rotary circulation is made possible by cutting off or rounding the corners of the buildings at the four street-corners and by a monumental tower erected in the center of the intersection.

This tower has on its first floor the apparatus and equipment of a fire company with entrances and exits for the street cars on the lower level. On the second floor are rooms for the firemen. An elevator takes visitors and sightseers to the observation platforms, below which is a gigantic clock. On the top a powerful searchlight is installed.

This plan calls for the smallest amount of condemnation of private property; while the beautifying of the streets would tend to increase the real estate values in the neighborhood.

[1]The terms and results of this contest were published in "Engineering News," June 3, p. 1096.





METHOD FOR RELIEVING CONGESTED TRAFFIC, WHICH WON FIRST PRIZE OF $300

Results of Magnetic Survey of United States—Observations have been made at more than 1,000 new stations and 200 repeat stations since the publication in 1910 by the United States Coast and Geodetic Survey of a report containing its isogonic chart, based upon the magnetic survey of the United States which was begun in 1899. The results are given in Special Publication No. 33, Serial No. 18, of the Survey, on: "Terrestrial magnetism—Distribution of the magnetic declination in the United States for Jan. 1, 1915, with isogonic chart and secular change tables." The plan for this work contemplated, first, a general magnetic survey of the country, with stations 30 or 40 miles apart, and, second, the addition of more stations in magnetically disturbed areas. It also provided for observations at a sufficient number of "repeat" stations to determine the change in the magnetic elements from year to year. The work has now advanced to the point where observations have been made at a great majority of the county seats, and the examination of areas of marked local disturbance is in progress. The isogonic chart is a map on which lines are drawn through places at which the values of the magnetic declination are the same. The present chart is based on about 6,000 values of declination, including about 800 in Canada and 300 in Mexico and the West Indies.

Double-Deck Bascule Bridge Over Chicago River

By Hugh E. Young*

SYNOPSIS—The new Lake St. bridge over the Chicago River will be a double-leaf bascule of 245 ft. span, carrying an elevated railway on the upper deck and a roadway (with car tracks) and sidewalks on the lower deck. The bridge itself is of interest, and its construction involved specially interesting and difficult problems, since the elevated railway had to be kept in operation over the old swing bridge during the construction of the new bascule bridge.

The Lake St. bridge, on one of the main thoroughfares entering the business district of Chicago, crosses the south branch of the Chicago River just south of the turning basin at the junction of the north and south branches with the main stem of the river. The present bridge has a three-truss swing span, which was built as a single-deck structure in 1888 and strengthened in 1893 to carry an upper deck for the Chicago & Oak Park Elevated R.R.

The river channel is 235 ft. wide at Lake St., but the swing bridge interferes seriously with navigation, giving a clear channel width of only 65 ft. on each side of the center pier. The United States War Department ordered the removal of the bridge several years ago, as an obstruction to navigation, but owing to the desirability of avoiding interruption to elevated-railway traffic and the difficulty of arranging for a temporary means of crossing the river, the city authorities procured an extension of time. Before this was done, however, studies were made for an incline from the elevated structure to the street level just west of the river, the trains crossing the river on the Washington St. bridge (two blocks south) and then rising again to the elevated structure in North Market St. This scheme was abandoned, as it would be too dangerous to run five-car trains on the streets in the busy district.

It was decided therefore to construct the new bridge in such a manner that the elevated traffic could be continued over the old swing bridge, except occasionally for a few hours at a time and when the inconvenience to passengers would be at a minimum. Plans for this new bridge were well-advanced by the end of 1912 and provided for three railway tracks, but later the elevated railway company decided to have only two tracks. The changed plans and specifications were finished in June, and bids were opened on Sept. 18, 1913, but the lowest bid exceeded the estimate for the bridge.

Owners of patents for movable bridges then claimed that a more economical bridge could be built on their plans, and a commission of three engineers was selected in accordance with a resolution passed by the Finance

*Bridge Designing Engineer, Department of Public Works (Bureau of Engineering), Chicago.

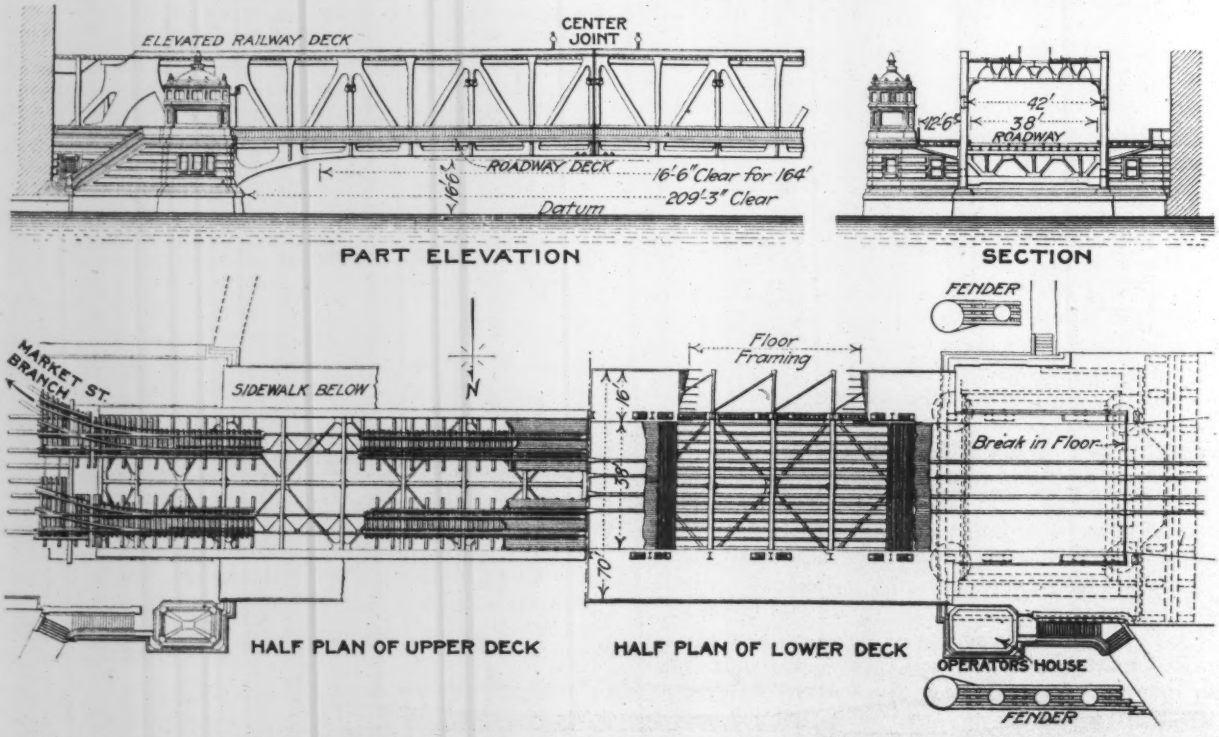


FIG. 1. ELEVATION AND PLANS OF THE DOUBLE-DECK DOUBLE-LEAF TRUNNION BASCULE BRIDGE ACROSS THE CHICAGO RIVER AT LAKE ST., CHICAGO, ILL.

This bridge will carry a roadway, sidewalks and street-car tracks on the lower deck, and a double-track elevated railway on the upper deck

Committee of the City Council on Oct. 24, 1913. This commission consisted of John Ericson, City Engineer; J. E. Greiner, Consulting Engineer, of Baltimore, Md., representing the elevated railway, and W. H. Finley, Chief Engineer of the Chicago & Northwestern Ry. Mr. Finley was selected by the other two members. Competitive plans and estimates were received by this commission for various types of bridges which could be erected without materially interfering with the operation of the existing bridge. These included a double-deck lift bridge and double-deck single-and-double-leaf trunnion bascule bridges.

The lift-bridge design placed the towers straddling the elevated structure on the approaches. The lift span could be erected in place in the open position or erected at the north side of the turning basin and floated into place on scows. The bascule bridges could be erected in the open position without interfering with the swing bridge, by omitting part of the floor system, thus allowing the trains to pass between the trusses. When the bridge was ready to be lowered, traffic would be interrupted long enough to complete the floor system and remove the swing bridge.

The commission recommended a vertical-lift design submitted by the city. On considerations of public policy, however, the City Council recommended the double-leaf bascule bridge (according to the city's plans somewhat revised). Accordingly, the various bids were rejected and the plans and specifications were revised.

Description of the New Bridge

The new bridge (Fig. 1) will have the following main dimensions: 245 ft. c. to c. of trunnions, 217 ft. c. to c. of bearings; clear width of channel, 195 ft.; clear distance between masonry piers, 209 ft. 3 in.; length of counterweight arms, 39 ft.; truss spacing, 42 ft. c. to c.; width over sidewalks, 70 ft.; depth of trusses at center, 30 ft.; clear headway over the water, 16 ft. 6 in. for a width of 164 ft. The lower deck, 70 ft. wide, has two 16-ft. walks and a clear roadway of 38 ft. with two lines of street-car tracks. The upper deck carries the double-track elevated railway.

This type of bridge was chosen mainly because it could be treated architecturally better than any other type, being symmetrical and having the counterweight under the roadway. The counterweight lowers into a tailpit between the river pier and anchor pier. The operating machinery will be placed under the sidewalks at each corner of the bridge and will be inclosed with concrete walls treated with suitable ornamentation. The new bridge is located symmetrically about the center of the present swing bridge and is being erected in the open position. During the construction, traffic on the lower (street) deck of the present bridge is discontinued, street cars being diverted to the Randolph St. bridge, one block south.

The new substructure consists of a tailpit and an abutment on each side of the river. This will be described in a separate article.

Temporary Supports for Elevated Approaches

After the street-railway company had removed trolley wires, rails, etc., from the swing span and approaches, the sidewalk brackets of the swing span were cut off with the acetylene torch, in order to obtain a wider channel with the bridge opened. The operator's house, situated over the sidewalks, had to be removed and a new one erected on the roadway of the lower deck. This involved no great amount of work as the bridge is operated electrically. The old protection (which was almost all broken away) was removed, and a new protection constructed to suit the new channel lines on each side of the center pier.

The approach spans on the street level were removed, the steel being cut with the acetylene torch and removed from the site by scows. Excavation was then started on both

FIG. 2. TEMPORARY SUPPORTS FOR END OF THE EAST APPROACH OF ELEVATED RAILWAY

approaches back of the old abutment. The center part of the old east abutment was removed first. The ends of the abutment were left in place temporarily, as the columns of the elevated structure rested on them.

Timber bents were then erected under the elevated structure, as shown in Fig. 2, which illustrates the east approach. Bents were erected just back of the river pier and in front and back of the abutment. These bents consisted of 12x12-in. posts directly under each girder of the elevated structure, which rested on piles capped just above the water-level surface. Old foundation piles uncovered during the excavation were used for supporting the bents, if suitably located. These were first tested by placing jacks between the bottom of the 12x12-in. posts and the piles. The piles were observed for settlement under this load, and if none occurred during an interval of about a day they were considered suitable for use.

The number of these old piles was due to the fact that, previous to the construction of the present bridge (1888), there had been at least two bridges, both supported on pile foundations. These piles were of a kind not common today, ranging from 18 to 24 in. in diameter at the butt. They were in a remarkable state of preservation, being practically as good as when driven, which must have been nearly 50 years ago. The bents were capped with 12x12-in. timbers, braced with 2x12-in. sway bracing. A batter pile was used in the bent at the river pier.

The columns of the elevated structure were supported on girders spanning the space for the tailpit. These girders rested on groups of piles driven in line with the first and second bents of the elevated structure east of the swing span, as shown in Fig. 3. Each girder consisted of two separate plate girders connected by cross-bracing. Each girder had a 96x¼-in. web plate and four angles 6x6x$\frac{7}{8}$ in.; it was stiffened at points of local load and about every 4½ ft. at other parts, by 5x3x⅜-in. stiffener

angles. Webs were spliced for moment. The overall length of these girders was 78 ft. The double girder for the rear bent was placed first, the abutments having been entirely removed. The girders supporting the front bent and the end of the swing were placed when it was convenient to close elevated traffic for a few hours, as the masonry of the old river pier had to be removed when the swing bridge was open and the bridge could not be closed again for traffic until a new end bearing could be provided.

This work was done July 3, 1914, traffic being closed on the elevated structure from 9 a.m. to 4 p.m. Passengers used the Canal St. station, two blocks west of the river. As soon as the girders were in place, the temporary timber supports under the elevated structure (Fig. 2) were removed.

After the construction of the tailpit, temporary timber bents were erected to support the elevated structure on the east side (Fig. 2). These rested on timbers laid on the pit floor. When these were ready for the elevated structure the box girders were transferred to similar positions on the west side. The girder under the first bent was transferred Dec. 29, when traffic was shut off on the elevated for 7½ hr. The temporary timber bents were removed as soon as the girders were in place.

The contractor for the superstructure started on Jan. 13, 1915, to erect falsework for the erection derrick on the east side and had this practically finished on Jan. 30. This falsework, or tower, required careful study, as the position of supports was not only limited by vertical headroom over the elevated structure, but by lateral clearances of a car swinging around the curve into the North Market St. branch (Fig. 1). This derrick is shown in Fig. 4.

The structural steel began to arrive at the site on Feb. 8. It was delivered on flat cars and unloaded at the railway yard on the north side of the turning basin (just north of the bridge site) where it was stored until needed. Thence it was delivered on scows.

The contractor started as soon as possible to erect the steel of the fixed parts upon which the movable structure rests. These parts consist of two carrying trusses, 48 ft. c. to c., parallel with and just outside the movable trusses.

The machinery girders are 7 ft. back from and parallel with the carrying trusses. The carrying trusses and machinery girders span from river pier to anchor pier, a distance of 53 ft.

The carrying trusses are the supports for the cross-girders (Fig. 5). They also carry the gear trains which are located opposite the racks in the rear arm truss members. The cross-girders are located 14 ft. back of the river pier; they carry the entire dead-load of the bridge, and have a span of 48 ft. c. to c. of carrying trusses, spanning the entire distance across the tailpits.

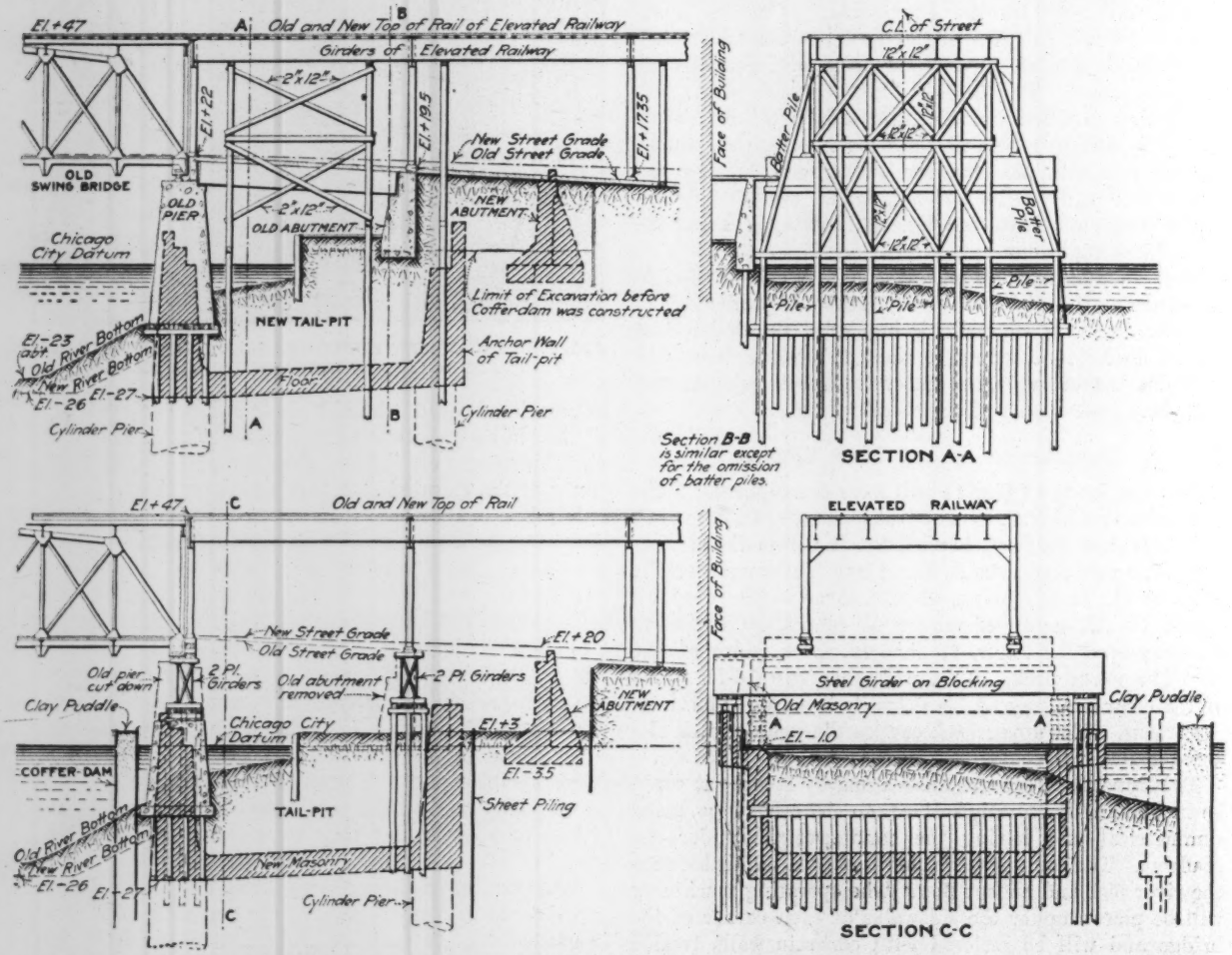


FIG. 3. METHODS OF SUPPORTING THE ELEVATED-RAILWAY APPROACH AT TWO STAGES OF THE WORK

At the time the superstructure contractor began work on the east side the elevated structure was supported on timber bents resting on the floor of the pit (as shown in Fig. 2). These bents were so placed that the contractor could erect the carrying trusses and machinery girders without difficulty. These trusses and girders, being outside of the elevated structure, could be handled by the derrick. The erection of the cross-girder, on account of its weight and its position under the elevated structure, was more difficult.

Additional falsework was built to place the cross-girder. This consisted of A-frames resting on the floor of the tailpit. On the frames were placed two 15-in. channels, forming a runway for sliding the girder across the pit. The girder was lowered from the A-frame to its final position on the carrying trusses by means of jacks.

The fixed portion of the new elevated structure over the tailpits will be supported on new columns, which rest on the carrying trusses about 7 ft. from the center line of the anchor pier (Fig. 1). These columns are in the same place as the old floor-beams, but are located a greater distance out from center line of structure. The old floor-beam was therefore lengthened in order to provide a connection for the new columns.

The steel columns in the bent at the river pier were also moved out, lengthened by splicing on portions of the

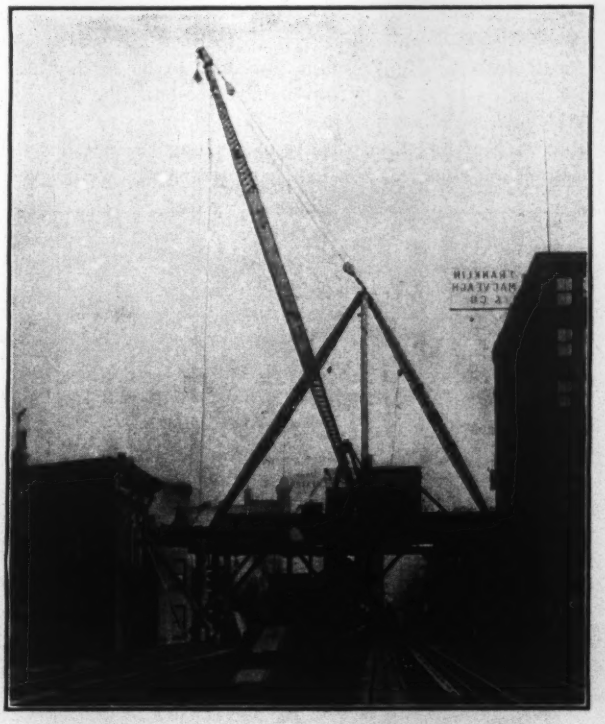


FIG. 4. STIFF-LEG DERRICK OVER THE ELEVATED RAILWAY APPROACH

old columns, removed from the bent near the anchor pier and carried down to a bearing on the carrying truss, the floor-beam of the elevated structure being lengthened as before.

The temporary timber bents under the elevated structure were then removed and the elevated structure carried on the new steel. The erection of the tail end of the bridge was then started, and part of the trusses had been assembled at the time a strike of the structural iron workers was called at the end of April.

During the week ending Apr. 17, 1915, the contractor began erecting his derrick on the west side. This was not placed over the elevated structure but in the tailpit, the mast resting on the floor and the stiff-legs being anchored to the sidewalls of the pit. A strike stopped the work in April and from that time until work was resumed on July 8, 1915, the elevated structure on the west side

FIG. 5. ONE OF THE TRUSSES OVER THE TAILPIT

rested on two temporary cross-girders, and on the east side on the new carrying trusses with the permanent columns in place for the bent near the anchor pier and temporary bent in place near the river pier.

The leaves will be erected in the open position, a portion of the floor system being omitted to permit of passage of trains. When the leaves are lowered the two spans of the elevated structure over the pits will be removed and the floor system on the upper deck completed.

Engineers and Contractors

The work is under the Department of Public Works, the head of which is W. R. Moorhouse, Commissioner of Public Works. The City Engineer, John Ericson, is head of the Bureau of Engineering, and Thomas G. Pihlfeldt is Engineer of Bridges and Harbor. The final plans were prepared in the Designing Section, under the immediate direction of A. von Babo, Engineer of Bridge Design, and the writer. The construction is supervised by the Construction-by-Contract Section, under Clarence S. Rowe, Assistant Engineer, and the resident engineer on the work is William A. Mulcahy, Assistant Engineer.

The contract for the substructure was awarded to the FitzSimons & Connell Dredge and Dock Co., of Chicago, on Mar. 14, 1914. The contract for the erection of the superstructure was let Mar. 18, 1914, to the Ketler-Elliott Erection Co., of Chicago. The contract for the steel was let to the American Bridge Co.

Raising the Submarine F-4

By J. A. Furer*

SYNOPSIS—On Mar. 29, 1915, the United States submarine F-4 sank outside of Honolulu Harbor in 300 ft. of water. Because it was desirable that the Navy Department should know the cause of the sinking, and in order to recover the bodies of the men who went down in the boat, the unprecedented task of raising so large a body from so great a depth was attempted. In this article Naval Constructor Furer, who planned the salvage methods, designed the equipment and directed the operations, tells how the work was successfully carried out.

The salvage of the submarine F-4 was unique in several respects. Much larger totally submerged vessels have been raised from shallow water, but none has ever been brought up from a depth of 300 ft. A few smaller vessels have been raised from depths of more than 200 ft., but only out of inclosed waters. The previous record for depth was the salvage of a small wooden tug, weighing perhaps 125 tons submerged, which sank in about 250 ft. of water in Puget Sound. The weight to be lifted in the case of the F-4 was 260 tons.

The principal difficulties of the salvage problem were the great depth of water in which the vessel lay, the weight which had to be lifted and the open-sea exposure. The vessel sank in 300 ft. of water outside of Honolulu Harbor, where there is no protection from southerly weather. While high winds from the south are unusual, there is nevertheless always a ground swell which is liable to develop into a heavy sea without warning.

For obvious reasons the customary salvage methods could not be applied in this case. The only plan offering reasonable assurance of success was to lift the vessel mechanically and to tow it into shallower water at the same time.

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Preliminary Operations

Two bottom-dumping mud scows (Fig. 2) were rented from a local dredging concern; on each of the scows two specially constructed windlasses were installed. On account of the great depth of water, securing lifting gear to the submarine was impracticable. It was therefore necessary to sweep cables under the vessel and to bring both ends of each sling to the windlasses. Four cables were used, two of which were placed about one-third the length of the vessel from the bow and the other two in a similar position aft. The vessel was therefore lifted in the loops of the four cables. Chain had to be used for the loops of the cables eventually, as will be described later.

Wire cables of sufficient strength to lift the vessel were difficult to find. The assumption had to be made that even when lifting with four cables one-half the weight of the submarine would often be carried by a single sling, on account of the impossibility of keeping the windlasses in step. Then, also, the loads on the slings were live-

FIG. 1. PREPARING TO TOW IN THE SUBMARINE F-4 SUSPENDED FROM PONTOONS

loads—very much so, in fact, because of the swell. Two galvanized-wire hawsers 2½ in. in diameter, one plow-steel hawser 2⅝ in. in diameter and one plow-steel hawser 2 in. in diameter were finally procured. All these hawsers were about 900 ft. long.

The construction of the windlasses presented a number of difficulties, due to lack of manufacturing facilities. Sugar-mill rolls are fortunately carried in stock in Honolulu. These answered the purpose of a combination windlass shaft and drum, as they were 15 in. in diameter. This diameter was theoretically far too small for the wire cables used, but in no case did a sling fail at the windlasses as the result of stranding. Naturally the short nip ruined the cables for further use over the length affected.

The turning effort was applied to the windlasses by means of a bull-wheel built up solid of steel plates. A cast-steel wheel would have been cheaper and fully as good, but could not be manufactured locally. The bull-wheels were fitted to the square ends of the rolls, thus doing away with a key. Power was supplied by a two-drum, 8x10-in. hoisting engine installed on each scow. The drum lines consisted of ¾-in. plow-steel wire rove up to triple blocks. This purchase, together with the multiplication of power due to the diameter ratio of the bull-wheel and windlass barrel—namely, 50 in. to 15 in.—was sufficient to wind up the load on one of the scows. On the other, on account of the design and condition of the engine, a luff had to be clapped on to the purchase to further multiply the power.

The distance between the triple blocks placed a limit of three turns on the number of revolutions of the windlasses obtainable without fleeting the tackles and rewinding the bull rope. When the running block of the purchase had reached the end of its travel, the windlasses had to be locked to keep them from unwinding. The tackles were overhauled and the bull rope was unshackled for rewinding on the spool by hand. The locking device consisted of a nickel-steel pin, which was slipped through a hole in the bull-wheel disk. The ends of the locking pin rested on pillow blocks provided for the purpose. Four holes were bored in the wheels so as to make it possible to lock the windlasses every quarter turn. A pawl and ratchet would have given a greater range of locking positions, but would have introduced undesirable elaboration into the design and construction of the gear.

Five 30-in. I-beams were used to span the mud pockets of the scows. On these, cast-iron pillow blocks for supporting the windlasses were installed. The shafts were supported at the ends and in the middle. The outside I-beams carried the locking-pin pillow blocks. Stiffeners had to be fitted in the wake of the shaft bearings to prevent web crippling. Heavy angle irons were bolted across the I-beams to counteract racking. The middle I-beam was supported throughout its length by one of the mud-pocket bulkheads, but special timbering had to be fitted under the end beams to prevent deflection. The I-beams needed were fortunately found in a lot of structural steel delivered for a coaling plant in process of erection at Pearl Harbor. It so happened that the beams were almost exactly the ideal length for this job.

The ends of the cables were brought up through the mud pockets of the scows and secured to the windlass shafts by heavy hook bolts. They were further backed up by cable clamps to prevent slipping. Three dead turns were also allowed on the shafts before taking up the load.

Cable-Sweeping Operations

The wire cables were swept under the vessel by means of tugs. The ends were then temporarily taken to a dredge from which the boom and bucket gear had been removed. This craft was anchored at the inshore end in the usual manner, but on account of the great depth of water could not conveniently be anchored at the other end. After the first cable had been swept under the submarine and taken to the dredge this served as the offshore mooring. The dredge was selected as part of the salvage plant because it was equipped with a powerful engine, geared to six cable drums. A central unit of this kind was needed for a number of reasons, but principally because it was impracticable to transfer the cables from the tugs to the windlasses direct, as it was never certain that the loop of the sling had been swept to the desired location under the vessel until an inspection had been made by the divers. It was comparatively easy to rehandle the cables when changes in location had to be made, once the ends were on the dredge. This was usually accomplished by leaving one end secured by a chain stopper to a drum line and transferring the other end to a tug, which then made the new sweep.

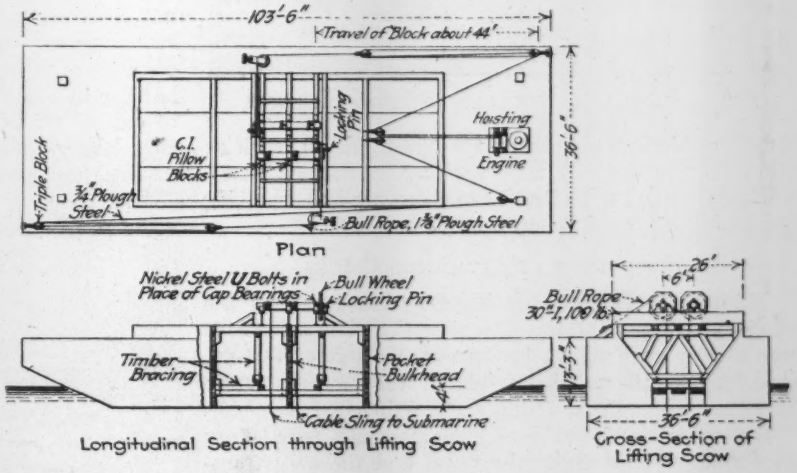

FIG. 2. DETAILS OF SCOW USED IN LIFTING F-4 FROM 300 FT. TO 50 FT. OF WATER IN HONOLULU HARBOR

Deep Diving Accomplished

The divers, while the vessel was in 300 ft. of water, set a new record for depth. It was possible to send men down to this previously unattainable depth only by the use of special methods. The Bureau of Construction and Repair of the Navy Department had been experimenting for some time on deep-sea diving. It so happened that these experiments were brought to the point of practical application just before the accident to the F-4. Four divers, in charge of the officer who had been conducting the experiments, were ordered from the New York Navy Yard to Honolulu for this work.

The diver does not wear a suit of special character for working in great depths. The difference as compared to shallow-water procedure lies entirely in the method of supplying air to the helmet and in the scientific restoration of the diver's body to the normal state by gradual decompression as he comes up from deep water. Air is supplied from flasks charged to a high pressure—suitably reduced before being delivered to the diver's helmet. The dangers in deep-sea diving are due principally to the absorption of nitrogen by the fluids of the body, on account of the high pressure to which the lung tissues are subjected, and to the extreme exhaustion accompanying any kind of manual labor. For the latter reason the divers

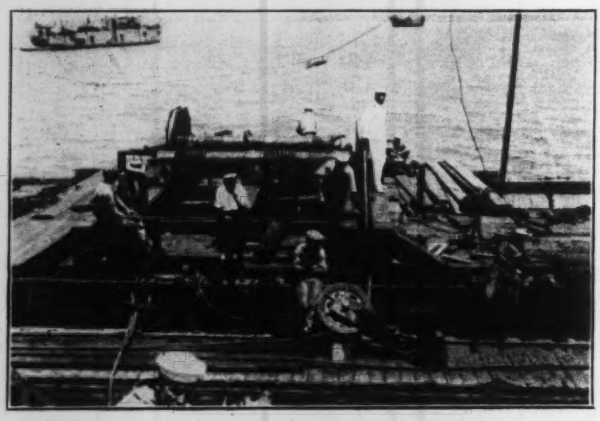

FIG. 3. VIEW OF WINDLASS RIGGED ON SCOW

could not do heavy work at the 300-ft. depth, such as can easily be done by men working in shallow water. Their duties had to be limited to observing and reporting the conditions found below.

Difficulties in Attaching Cables

Placing the slings in satisfactory locations was the most difficult part of the salvage work. The submarine was a very small object to lasso at a depth of 300 ft., especially as the exact location of the bow and stern could not be predicted within perhaps 100 ft.

But after innumerable discouragements four slings were finally swept under the vessel and the ends transferred from the dredge to the scow windlasses. This took from Apr. 10 until Apr. 21. On Apr. 22 lifting the submarine by winding up the cables on the windlasses was started. As the cables were wound up, a towing strain was kept on the scows, thus bringing the submarine into shallower water.

After lifting about 12 ft., one of the cables parted in the loop as a result of chafing on the bilge keels. This cable was one of the first to be placed and had consequently suffered from chafing for almost two weeks, due to the continual motion of the dredge and of the scows in the swell. The broken sling was replaced and lifting was continued until the vessel was in 275 ft. of water. Bad weather now set in and accelerated the impairment of the cables, causing them to carry away one by one. It was apparent that chain would have to be used for that portion of the slings in contact with the vessel.

The use of chain for the loop of the slings was considered when the salvage plan was first being developed, but was rejected, because chain does more damage to the vessel and is much harder to place than wire rope. These disadvantages had now to be accepted. A 15-fathom shot of 2⅝-in. chain was accordingly shackled in to form the loop of each sling. The dredge was again moored as before by sweeping 1¾-in. wire hawsers under the bow and the stern of the submarine and bringing the ends over the corners to the drum lines. The chain slings were finally placed in the same locations as had been occupied by the wire-rope slings. Bringing these combination slings to position was considerably more difficult than placing the wire cables, because they were even heavier and more awkward to handle than the latter. After working 21 days four slings were again in place under the vessel.

As the submarine was lifted a towing strain was kept on the dredge by a tug. This in turn brought a towing strain on the submarine by way of the two 1¾-in. mooring cables. The arrangement proved more satisfactory than towing directly on the scows, because it permitted the scows to ride in their normal state of equilibrium.

Once the slings had been made fast to the windlass drums, lifting was fairly rapid. After the windlass shafts had been filled with one layer of cable it was necessary to cut off the wound-up portion and to shift to a new hold under the hook bolts. It was inadvisable to wind up a second layer, because of the reduction in diameter ratio of the bull-wheel and windlass barrel which this would have entailed. As it was, there was only barely enough power available to wind up the load. One layer of cable corresponded to a lift of 58 ft. The shafts could be filled in about two hours of actual lifting, but the work of cutting off and shifting to a new hold took considerably longer. The cables were cut off by means of an oxyacetylene torch.

In spite of every effort, one of the stern lifting slings could not be located quite as far aft as desired when it

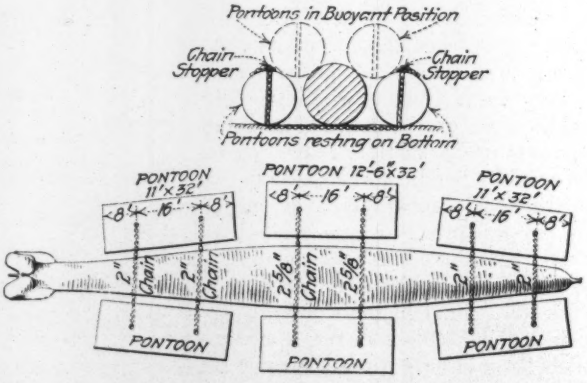

FIG. 4. ARRANGEMENT OF PONTOONS IN RAISING F-4

was put on; consequently the two after slings did not plumb the mud pocket through which they passed. This was immaterial in deep water, but as shallow water was reached the slings began to bind on the framing of the pockets. When a depth of 50 ft. was reached it became necessary to shift the sling to a more vertical position.

Scow Method Abandoned

While this work was going on, a heavy ground swell set in very suddenly. The swell increased rapidly and in a short time high surf waves were breaking near the submarine. The waves and the undertow from the reef caused the scows to charge back and forth with tremen-

dous momentum. The after-sling could not now be replaced in time to resume operations. It was apparent that considerable damage would be done to the submarine by the slings and that possibly the entire plant would be wrecked if an attempt were made to ride out the bad weather. The slings were accordingly cast off and the scows towed into the harbor.

The heavy seas continued for a number of days. As soon as the swell had subsided sufficiently, divers were sent down to examine the submarine. They reported that the forward slings had ruptured the shell and had caused the collapse of some of the framing one-third of the distance from the bow. This made it unsafe to continue operations by the windlass method, as there was danger of breaking off the forward end of the vessel while passing through the channel. This would have blocked the harbor to navigation.

As the submarine now lay in somewhat less than 50 ft. of water, it was possible to apply the pontoon method of lifting, but it was still impracticable to follow the usual procedure of lifting a few feet and towing to a new landing, because conditions were such that the vessel had to be raised in one operation to a draft of not more than 25 ft. This draft was fixed by the depth of water over the blocks of the dry dock in which the vessel had to be landed.

Details of Pontoon Method

The plan adopted to meet these requirements consisted of the use of six specially designed pontoon cylinders sunk alongside the submarine, as shown in Fig. 4. The plan

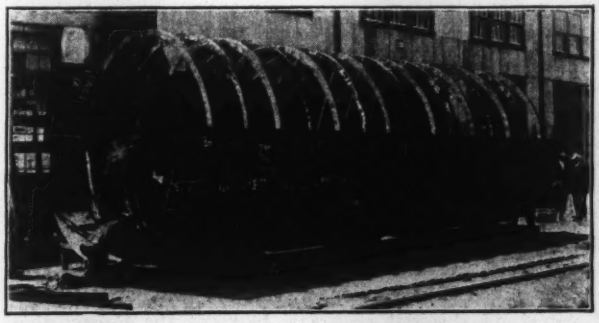

FIG. 5. PONTOON UNDER CONSTRUCTION

further called for the use of six chains rove under the vessel and passing through hawse pipe in the pontoon cylinders. The arrangement consisted in effect of lifting the submarine in a cradle made up of six chains.

Four of the cylinders were 32 ft. long by 11 ft. in diameter; the other two were of the same length, but 12 ft. 6 in. in diameter. The large cylinders were used amidships. The combined lifting capacity of the six pontoons was 420 tons. A margin of 160 tons was allowed for breaking the vessel away from the bottom and for any failure to realize all of the buoyancy available in the pontoons due to cockbilling.

Each cylinder was divided into two compartments by a transverse, water-tight bulkhead so as to facilitate control in sinking. A 4-in. flood and discharge valve was installed in each end bulkhead close to the bottom. Air valves were fitted on top of the cylinders for blowing out the water and for venting each compartment while flooding. Eight feet from the ends 12-in. hawse pipes were fitted through the pontoons. The cylinders were built of ⅜-in. plates ruggedly framed on the inside to resist the large stresses to which they were subjected. Fig. 5 shows a cylinder under construction. On the outside the pontoons were sheathed with wood so as to protect the plating from local damage due to chafing and contact with sharp projections on the submarine. The wood sheathing proved extremely valuable during the salvage work. Without this protection against damage it is probable that the pontoons would have sprung leaks which might have been fatal to the success of the work.

The chains were first of all worked under the submarine in predetermined positions—two forward, two amidships and two aft. The two chains of a pair were spaced 16 ft. apart so as to correspond to the distance between the hawse pipes. The pontoons were planted by means of a wrecking scow which was moored accurately over the submarine. The two cylinders of a pair were towed to the scene of operations and placed one on each side of the scow, directly over a pair of chains lying on the bottom.

Chain-Attachment Operations

The ends of the chains were now fished up through the hawse pipes and the cylinders submerged by opening the flood valves. They were kept under control while sinking by means of 5-in. manila lines made fast to the ends and taken to the hoisting engines on the scow. After the pontoons had landed on the bottom the chains were adjusted so as to leave the necessary amount of slack to permit the pontoons to rise just clear of the vessel on becoming buoyant. A clamp was now fitted to each chain by the divers, just above the hawse pipe. The clamps consisted of two steel castings, molded to the shape of the chain links and of such length that they spanned the hawse pipes. By means of four heavy bolts the two halves of the clamp were drawn together. These bolts kept the clamps from spreading and the chain from slipping through when subjected to the lifting strain. Fig. 6 shows a clamp in place.

After all the six cylinders had been landed on the bottom alongside of the vessel and the clamps had been secured by the divers, the unwatering process was started. For this purpose torpedo air flasks, charged to a pressure of 2,150 lb., were placed on a coal barge. The flasks were piped to an expansion chamber, which in turn was connected to a manifold. Twelve ¾-in. air-hose lines were led from the manifold valves to the blow-out valves on top of the pontoons. A pressure of 35 lb. was used at the manifold for blowing out the water while the cylinders were resting on the bottom. The unwatering operation had to be watched very carefully so as to avoid the danger of springing the heads of the cylinders when the external water pressure was relieved on emerging.

The method proved entirely successful. The work of placing the chains under the submarine was started on Aug. 21. All the chains were in position on Aug. 25. It then took one day to place each pair of cylinders. Fortunately, good weather prevailed during this rather precarious phase of the operations. On Aug. 29 everything was ready for blowing the water out of the pontoons. This operation took about two hours from the time the air was fully turned on.

One end of the submarine came up slightly ahead of the other, as was to be expected. The bow pontoons on emerging were considerably cockbilled. The cause of this

was that the chains were not attached to the submarine but were simply rove under the vessel from the pontoon on one side to its mate on the other side. One end of each pontoon was bound to become buoyant slightly ahead of the other end, no matter how far the subdivision into compartments might have been carried. The buoyant end then pulled the slack chain through under the vessel. The natural result was that the pontoon on the other side cockbilled in the opposite direction. As long as there was a sufficient margin of buoyancy in all six pontoons the cockbilling made no difference, as enough water could be blown out of the high ends to provide the lift needed. The low ends could of course be completely unwatered. Once the pontoons emerged, they immediately adjusted themselves automatically, as the high ends ceased to be water-borne and therefore exerted no pull on the chain.

FIG. 6. CHAIN CLAMP IN PLACE ON PONTOON
These clamps were secured by the divers under water with the cylinder lying on the bottom

This permitted the buoyancy of the low end of the opposite pontoon to assert itself, thus causing the chains to render. Fig. 1 shows all the pontoons on the surface, with the submarine suspended in the chains.

The question suggests itself why the pontoon method, which was finally adopted, could not have been used originally for bringing the vessel to the surface. This would have been impracticable because of the great depth of water in which the submarine lay at first. Whereas sinking the pontoons alongside the vessel and fitting the chains was not particularly difficult in 46 ft. of water, the task would have been quite impossible in 300 ft. of water. The divers from the submarine flotilla had to work under water from 5 to 9 hr. a day from Aug. 21 to 29 while placing the chains under the vessel, securing the clamps after the pontoons had been lowered, closing flood and vent valves and later on connecting the hose leads for blowing out. This work could not have been done at a depth of 300 ft., as most of it was extremely arduous and fatiguing.

With the exception of the civilian employees who operated the hoisting engines, most of the work on the water was done by the personnel of the submarine flotilla. The men and officers did this work splendidly, under the most trying conditions. The windlasses were built and installed at the Pearl Harbor Naval Station. The pontoons were built at the Navy Yard, Mare Island, from designs prepared at Pearl Harbor, as there were insufficient material and labor available in Honolulu to permit building them at the latter station.

Observing Contractor Sketches Trip to the Coast

By Contractor

I recently visited the Panama-Pacific International Exposition, and on my way to and from the Coast I kept an eye out for construction work under way. Contractors who are wondering whether they are going to nail a winter meal ticket will be pleased to learn that many of their brother contractors are busy with large contracts.

West of meridian 101 nearly all crops are raised by the dry-farming method or by irrigation. In western Kansas and eastern Colorado, along the Union Pacific and the Rock Island, there are numerous dry farmers and prairie-dog towns and now and then a bunch of steers without chaperons (cowboys). The latter have all gone to the movies. The country roads in that section reminded me of some coffee I had on a Santa Fé train. This beverage consisted of a very weak solution of irrigating water and some white coloring matter (alleged to be cream). I complained to the waiter, but he said that it was all the cows could do there to get along by themselves without giving up anything. It looked about the same with the dry farmers. They were not giving up much for roads, and from the appearance of the country there wasn't much to haul over the roads anyway.

Denver, Colo., is building a new union depot and an X-shaped viaduct of concrete and steel, 3,000 ft. long on one leg and 5,000 ft. long on the other. It is built where two streets cross each other. In other respects the city appeared to be finished as regards construction. Brick and stone are the prevailing building materials, there being very few wood structures. Trees, lawns and gardens are irrigated. Although the streets are well paved and lighted, the street-car tracks are narrow-gage and the electric cars look as antiquated as the horse cars in New York City. A system of good roads runs from Denver to scenic points in the mountains, and the Mountain Telephone Co. each day posts a bulletin that indicates the condition of the roads in each district.

Not much construction was under way at Colorado Springs. I think it only fair to warn the tourist that when he strikes this town he is in the midst of highwaymen, and if he gets away with anything it isn't their fault. The Crystal Park drive did not appeal to me, as I had already seen enough of the plains. I was out to see the country, however, and so climbed aboard the automobile. A prize stunt on this trip is to be compelled to turn the vehicle around in narrow quarters; but 50 yd. of additional excavation would have given plenty of room for the turn.

The Cripple Creek short line between Colorado Springs and Cripple Creek was built to reach the mines, but it does a considerable tourist business as well. The grades and curves are about the limit and make one believe that the engineer who laid them out must have had a crooked transit or used a cross-eyed mule, as they follow the line of least resistance from a construction standpoint. There is a trolley line about 10 mi. long in this vicinity that is claimed to be the highest in the world, its elevation being 11,200 ft.

To construct the Denver & Rio Grande R.R. through the mountains would seem no great engineering task

at the present day, but no doubt at the time it was built it was a serious problem to provide supplies. The problem of a water-supply and the Indian menace were items too important to be forgotten. The old line over the Utah desert has been revised in the past few years. That part over Soldier's Summit has been abandoned, a cut-off having been constructed in which distance and curvature were sacrificed to obtain a lower grade.

In the Yellowstone Park, Government engineers are doing considerable road work, using teams with fresno scrapers. Reinforced-concrete box culverts are being constructed where necessary, utilizing for the concrete the gravel found in the vicinity. Quite a stretch out of Yellowstone, Mont., is being macadamized. The United States Engineer's Office is at Mammoth Hot Springs, Yellowstone Park, Wyo. Autos were let into the park for the first time on Aug. 1. Tanks are located every few miles, and the Government tries to keep the roads sprinkled.

At Victoria, B. C., there were two drill boats, a pile-driver and a big dipper dredge preparing for the large docks to be built there. At Vancouver the Canadian Northern Ry. has planned to build some large docks costing several millions; but when I was there in August things were rather quiet.

From Seattle to San Diego, Calif., there is a series of stretches of road known as the Pacific Highway, which was under construction. Through the Oregon mountains I think macadam is used on this highway, but in California the road is of concrete, with asphalt top. The Pacific Highway follows the line of the Southern Pacific Ry. through the Sacramento Valley, most of the way to San Francisco. On the concrete sections expansion joints were placed about 250 ft. apart. About halfway between the joints I noticed a break, as though the joints had been placed too far apart. The extreme heat of the Sacramento Valley would test the expansion of anything. It was 112° F. when I passed through en route to San Francisco, but before sundown there was steam heat on the train, made necessary by the ocean breezes.

San Francisco and the exposition have already been described by many persons, and I will not add my voice to the tumult. As for contract jobs in the vicinity, the Twin Peaks tunnel is under way, and there is a large sewer being built to the ocean outlet between Sutro Heights and Golden Gate Park. It is about 4,500 ft. long and lined with concrete. The contractor informs me that he had successfully shot concrete with air 3,000 ft. on this job; while I was with him they were blowing it 600 ft. The same man has the contract for lining the Twin Peaks Tunnel. He says that he is not going to use air for concreting in the tunnel. The transportation system of the city comprises trolley cars and a few cable cars, jitneys and some of those Manhattan busses. The crowds were handled very well. The hills are too steep for trolleys, so I suppose the cable cars will always be there. There is one hill near the exposition that is said to have a 32% grade.

Los Angeles has a scheme for saving the sewage for fertilizer and the water for irrigation. In the West you might shoot a man and get away with it, but you must not waste any water. The press is agitating a big appropriation for flood control of the Los Angeles River. When I saw the river there wasn't enough water in it to water a mule. The city and county have very good roads, with concrete base and asphalt top.

San Diego is the cleanest and brightest spot on the Coast, but there is not much doing at the local exposition. It was a big mistake to hold the two expositions at the same time. The paving in San Diego is asphalt and a sort of vacuum cleaner is used for street-cleaning.

I made a two days' stop at Grand Canyon. From a construction man's point of view, the canyon has a great face to it if one wanted to open a quarry.

In New Mexico the creek and river beds do not contain enough water to wet a mosquito's feet, but as the railway bridges are long there are probably times when water is superabundant.

Illinois Utilities Commission Has Water-Works Rules

Water-service standards were established in August by the Illinois Utilities Commission. This is the second state to establish definite rules for water service much like those generally adopted for gas and electric supplies. These rules cover about the same ground as those recently adopted in Oregon, except that they make no provision as to the security of domestic supplies and do not specifically require adequate pressure. They do go beyond the Oregon rules, however, in the matter of interruptions to service.

Rule 1 provides that records and reports required by these rules shall be preserved for at least three years. Rule 2 requires the utility to keep a record of each meter, showing make, size, style, number, date of purchase and the results of every test. Rule 3 requires utilities having 300 or more customers to maintain recording pressure gages. Causes of extreme variations are to be noted on the gage record. Other gages must be set at points fixed by the commission. Rule 4 requires that bills for meter service shall show the date of meter readings and the total quantity supplied. The utilities-operating rules are to be printed on the reverse of the bill.

In Rule 5 prompt reëstablishment of interrupted service is demanded. Interruptions for working on distribution lines are to be done at times of least inconvenience to consumers and only after six hours' notice to consumers and fire departments. In Rule 6 written acknowledgments of complaints and full and prompt investigation are demanded. A record must be maintained, showing complainant, nature of complaint and adjustment.

The rest of the rules relate to meter testing. Sufficient laboratory or shop equipment is required to make the meter tests demanded. Runs are to be made at ⅛, ½ and full flow. Not more than 4% excess registration on ⅛ and ½ flow is permissible and not more than 2% on full flow. The average error must not be more than 2%. Tests may be made at the place of installation, provided the method employed is approved by the commission. Untested meters are not to be placed in service. The time that a water meter may be kept in service without testing is 10 yr. (or the passage of 100,000 cu.ft.) for a ⅝-in. meter, six years (or 300,000 cu.ft.) for a 1-in. meter and four years for larger sizes. A meter must be tested free on request once in 12 months. For more frequent tests a fee of $2 to $5 may be imposed. The commission will test a meter on application and if the meter is too fast the utility must pay the fee.

How Low Fixed Charges Favor Centrifugal Pumps

By G. H. Gibson*

A pumping unit can be highly efficient in the conversion of heat units to work, and still have a smaller money economy than another unit of lower thermal efficiency. A good example of this fact is supplied by two notable steam pumping units which were installed and tested during the last year. One was a steam-turbine-driven centrifugal pump at Cleveland, Ohio, and the other a triple-expansion reciprocating pumping engine at St. Louis, Mo.—each probably being the most efficient representative to date of its respective type.

The Centrifugal Pumping Unit

The steam-turbine-driven centrifugal pump (designed and built by the De Laval Steam Turbine Co. and installed by Dravo-Doyle Co.) is at the Kirtland Pumping Station of the City of Cleveland and consists of a turbine of 14 pressure stages, running at 3,600 r.p.m. and driving two 24-in. centrifugal pumps at a speed of 600 r.p.m. through a double-helical speed-reducing gear. The specifications required the pumps to deliver 30,000,000 gal. per day against a total head of 206 ft., some 18 ft. of which was to be suction lift. It was guaranteed that when operating with steam at 150-lb.-gage pressure, superheated 100° F., the unit should develop a duty of 115,500,000 ft.-lb. per 1,000,000 B.t.u. The vacuum was not specified, as the contractor was required to supply the condenser. The unit was also designed to operate against a 250-ft. head.

Due to the nature of the subsoil, it was impossible to excavate deep enough for the condenser to be placed in the suction line, according to the usual practice. The condenser (designed and built by the Wheeler Condenser and Engineering Co.) was therefore designed for a pressure of 150 lb. per sq.in. and was connected in the discharge line. It is a water-works type, all of the water handled by the pump passing through the shell and the steam being condensed inside the tubes. The exigencies of available space and a desire to shorten as much as possible the connection between the exhaust flange of the turbine and the condenser made necessary two short-radius right-angle bends between the discharge flange of the pump and the water-inlet flange of the condenser. The condenser contains 2,120 sq.ft. of cooling surface and is served by a dry-air pump and a horizontal duplex hot-well and condensate pump, both pumps exhausting into an open feed-water heater. The condensing equipment was designed to provide a vacuum of 28 in., referred to a 30-in. barometer. This has been slightly exceeded in practice.

TABLE 1. RESULTS OF TESTS OF KIRTLAND CENTRIFUGAL PUMPING UNIT, CLEVELAND

	Dec. 22, 1914			Dec. 30, 1914
Began	9 A.M.	3 P.M.	4 P.M.	10 P.M.
Finished	3 P.M.	4 P.M.	9 P.M.	11 P.M.
Steam pressure, lb.	150.3	151.5	149.9	153.58
Corrected vacuum, in.	28.34	28.47	28.47	28.25
Discharge pressure, ft.	181.9	171.5	188.1	214.5
Suction lift, ft.	25.3	22.8	21.8	21.7
Suction-head loss, ft.	7.1	8.3	7.6	8.4
Total average head, ft.	207.2	194.3	209.9	236.3
Av. temp. of condensate leaving condensate heater, deg. F.	84.6	82.7	82.0	81.3
Av. temp. of condensate, heated by auxil. exh., deg. F.	105.1	102.0	102.2	102.0
Superheat in steam, deg. F.	86.2	86.6	74.6	102.6
Equiv. total heat supplied above temp. of condensate, B.t.u. per lb.	1171.7	1174.6	1168.3	1183.9
Total steam cons. per hour, lb.	14,975	14,908	14,998	16,372
Average pump r.p.m.	583.6	582.0	580.2	608.4
Av. rate of pumping, million gal. per day	29.60	32.40	30.38	30.30
Av. water, hp.	1077.0	1105.2	1120.4	1257.0
Duty, 1,000,000 ft.-lb. per 1,000,000 B.t.u.	121.53	124.96	126.78	128.40
Duty, 1,000,000 ft.-lb. per 1,000 lb. superheated steam	142.40	146.79	148.12	152.02
Steam per water hp., per hr., lb.	13.90	13.50	13.37	13.02
Overall thermal efficiency, %	15.6	16.1	16.3	16.5

The temporary nature of the installation also explains the character of the supply and delivery connections to the pump. In order to utilize a 48-in. suction line running from the well to a compound direct-acting pump installed on the other side of the building, a 48x48-in. T was inserted. As may be seen from Fig. 2, the location of this T, relative to the bottom suction opening of the pump, resulted first in a dead end approximately 30 ft. long beyond the point where the suction connection for the pump is taken off, and also the existence of a high spot or inverted siphon in the suction line rising to approximately 6 ft. To overcome the possibility of trouble from these sources, a vertical chamber was put on the 48-in. suction line, close to the outlet to the pump, and the top of this chamber connected to the air pump. This has worked successfully, as the pump operates quietly with a suction lift as high as 26 ft. when handling water at the rated capacity.

The turbine, gear and two pumps comprising the unit occupy a space approximately 10 ft. wide by 35 ft. long, measured over the foundations; and as they weigh altogether only 57 tons, the pressure per square foot of sur-

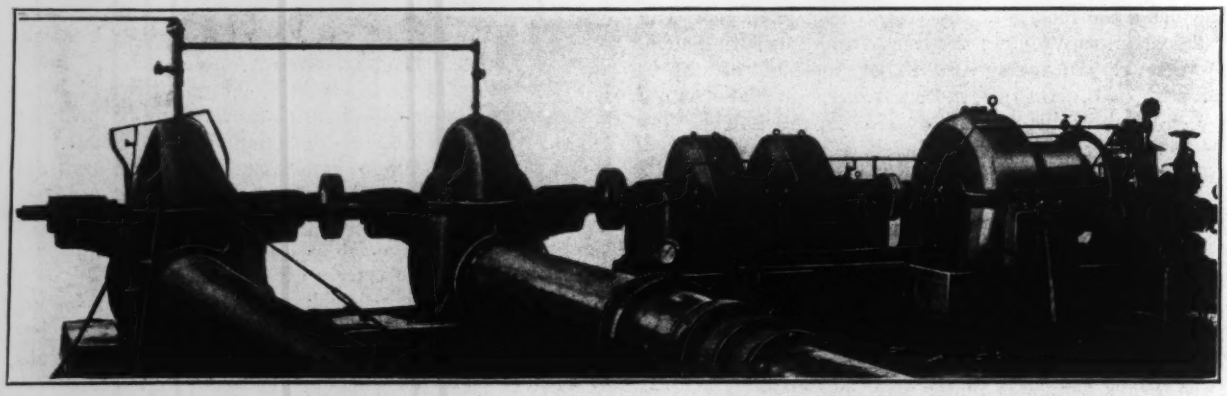

FIG. 1. GEARED TURBINE-DRIVEN PUMPING UNIT AT KIRTLAND STATION, CLEVELAND

*Tribune Building, New York City.

face is only about 326 lb., rendering the construction of foundations a comparatively simple matter in spite of the nature of the ground.

Tests of Centrifugal Unit

A preliminary test for duty was made under full load at the builder's shop, the results of which agreed within 1% with the results of the acceptance trials made at the Kirtland Pumping Station, Cleveland, on Dec. 22 and 30, 1914, a résumé of which is given in Table 1.

The third test most closely corresponds to the specified conditions upon which the guarantees were based. The duty guaranteed was equivalent to 136,500,000 ft.-lb. per 1,000 lb. of superheated steam, while the duty actually realized in this test was 148,121,000 ft.-lb., although the steam pressure was 0.1 lb. less than specified, the superheat was 15.4° less and the suction lift was 3.8 ft. greater—due to friction in piping which was not furnished by the contractor. In the fourth test, in which the conditions more nearly approximated those for which the unit was designed (with a view to the conditions under which it would ultimately be required to operate), a duty of 152,020,000 ft.-lb. per 1,000 lb. of superheated steam was realized, equivalent to 128,400,000 ft.-lb. per 1,000,000 B.t.u.

TABLE 2. COMPARISON OF KIRTLAND STATION AND BISSELLS POINT PUMPING UNITS

	Kirtland Centrifugal		Bissells Point Triple-Expansion
Capacity, gal. per day	30,000,000		20,000,000
Head, ft.	206		125 lb.-288.3 ft.
Suction lift, ft.	18		
Steam pressure, lb. gage	150		160
Superheat, deg. F.	100		100
Water hp. specified	1,081		1,013
Duty guaranteed, ft.-lb. per 1,000 lb. steam	136,500,000		195,000,000
Weight, including bed plates, tons	57		875
Space occupied, ft.	35x7x18		30.5x22x51
Price of unit, including condenser	$35,750		$193,697
Price plus bonus			$200,697
Date tested	Dec. 22, 1914	Dec. 30, 1914	Apr. 23-24, 1914
Test data	Test 3	Test 4	
Delivery, gal. per day	30,380,000	30,300,000	20,610,000
Head, ft.	209.9	236.3	297.7
Suction lift, ft.	21.8	21.7	
Steam pressure, lb.	149.9	153.85	159.43
Superheat, deg. F.	74.6	102.6	105.23
Vacuum, in.	28.47	28.25	28.00
Boiler hp. required	477.7	545.7	350.1
Duty developed:			
Ft.-lb. per 1,000 lb. steam	148,120,000	152,020,000	202,628,616
Ft.-lb. per 1,000,000 B.t.u.	126,780,000	128,400,000	166,719,796
Water hp. developed	1120.4	1257.0	1074.91

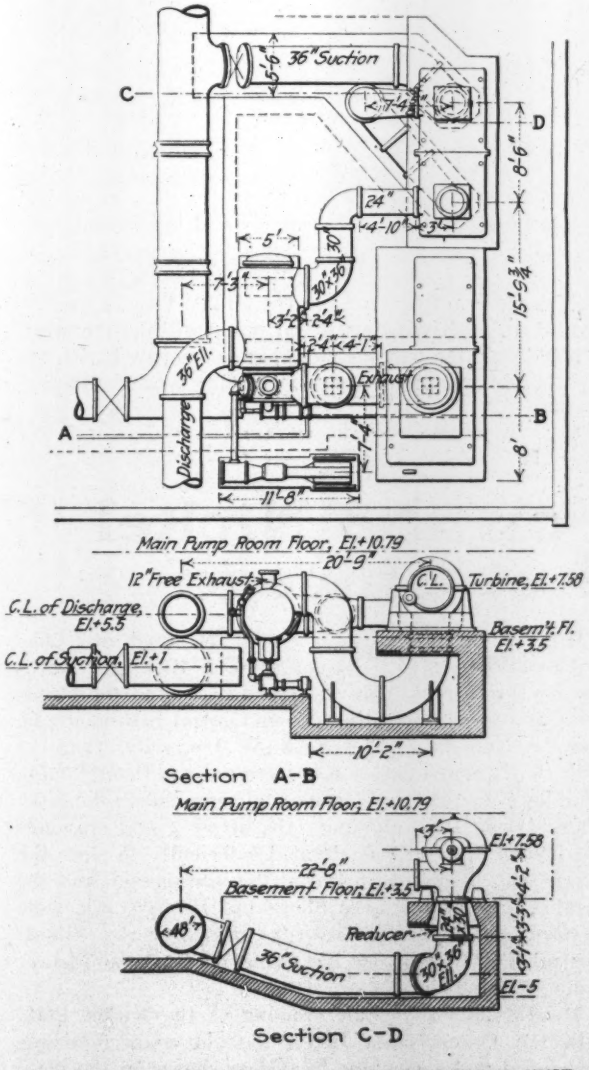

FIG. 2. PLAN AND SECTION OF CENTRIFUGAL-UNIT INSTALLATION, KIRTLAND STATION

Comparison with St. Louis Unit

It is instructive to compare the results of these tests with those of tests made eight months previously upon a vertical triple-expansion reciprocating pumping engine (Holly type) installed at the Bissells Point Station of the St. Louis water-works. It was designed to deliver 20,000,000 gal. per day against a pressure of 125 lb. per sq.in., corresponding to 1,013 water horsepower. The water horsepower corresponding to the Kirtland Station specifications was 1,081, so that the efficiencies and economies of the two units, each representing, so far as known, the highest development of its type, are properly comparable. The Bissells Point pumping engine was guaranteed to deliver 195,000,000 ft.-lb. per 1,000 lb. of steam at 160 lb. pressure and 100° F. superheat, and a bonus of $1,000 was to be paid for each 1,000,000 ft.-lb. of work done by the engine in excess of this duty, while a forfeiture of a like amount was to be deducted for each 1,000,000 by which the duty fell short of the guarantee.

The steam cylinders were jacketed and covered with magnesia insulation. The valve gear was of the corliss type, with poppet exhaust valves on the low-pressure cylinder. The water ends were of the single-acting outside-packed plunger type, arranged for direct flow, with removable-valve decks, containing 1,482 valves for each of the three pumps. Rubber valves with bronze stems are held on gun-metal seats by brass springs. The condenser, which is of the water-works type, with steam in the tubes, contains 1,800 sq.ft. of cooling surface, and the total weight of the unit, including a two-stage air compressor for supplying the air chambers, is 875 tons.

The foregoing particulars and the following test results are taken from an article in *Engineering News* of Sept. 3, 1914:

Steam pressure, lb.	159.43
Vacuum, in.	28
Water pumped in 24 hr., gal.	20,610,000
Superheat, corrected, deg. F.	105.23
Total head, ft.	297.703
Duty, ft.-lb. per 1,000 lb. of steam, without correction	202,628,616
Duty, per 1,000 lb. deducting for 5.23° superheat	202,105,616
Total heat consumed, including jacket and auxiliaries, B.t.u.	306,384,969
Duty, ft.-lb. per 1,000,000 B.t.u.	166,719,796
Water horsepower	1,074.91
Steam per water horsepower	9.77

As will be noted, the head pumped against, and also the water delivered, were somewhat greater than those specified in the contract. For purposes of comparison with this test, therefore, both the third and the fourth tests on the De Laval centrifugal pump have been taken. Table 2 compares the leading facts in regard to the two units and their performances.

To make a further comparison of these two units it would be necessary to consider installation at the same location, as the cost of buildings and foundations depends largely on local circumstances. The total weight of the reciprocating engine is over fifteen times that of the turbine-driven centrifugal pump, while the cubical space occupied is about ten times as great. In view of this, it may be assumed for comparison of economic results that the buildings and foundations for the reciprocating unit would in general cost four times as much as for the centrifugal unit, although they might be even more.

The cost of bituminous coal (13,000 B.t.u. per lb.) to the City of Cleveland is $1.64 per ton, whereas in St. Louis washed coal showing 11,000 B.t.u. per lb. is purchased for $1.69 per ton. For the purpose of comparison it has been assumed that both units are supplied with steam generated from the coal costing $1.69, which, if burned under boilers of 65% efficiency, would give a fuel cost of 13c. per 1,000,000 B.t.u. It has further been assumed that the nominal horsepower capacity of boilers installed will be the same as the boiler horsepower of steam used. Operation at 200% above nominal rating is now common, so that this gives ample spare boiler capacity. The interest rate upon money has been taken at 4%, maintenance and supplies for pumping engines and buildings at 2%, with 30 years as the probable life. This gives a total annual charge against engines and buildings, including depreciation or amortization, of 7.6%. For boilers the same rate of interest has been assumed, while maintenance and supplies have been put at 4% and the probable life at 20 years, making the total 11.3%. These assumptions give the following figures for comparison, using the results of the fourth test upon the centrifugal pump:

	Centrifugal Unit	Reciprocating Unit
Cost of buildings and foundations, assumed	$20,000	$80,000
Cost of boilers, settings and stack, assumed as $30 per nominal boiler horsepower	16,371	10,503
Annual interest, maintenance and depreciation charges on pumps and buildings	5,130	21,310
Annual interest, maintenance and depreciation charges on boilers	1,849	1,188
Total interest, repairs, maintenance and depreciation charges	6,979	22,498
Annual fuel cost of steam, at 13c. per 1,000,000 B.t.u., based on full load 24 hr. per day, 365 days per year	22,030	14,540
Total annual cost per water horsepower, exclusive of attendance and supplies, assuming 100% load factor	23.11	34.45

As will be seen, the annual cost per water horsepower is $23.11 for the steam-turbine-driven centrifugal pump and $34.45 for the vertical triple-expansion reciprocating pumping engine. In neither case has any charge been made for supervision and attendance, although there can be no question that in view of the great complexity and great number of valves, packings and other parts connected with a reciprocating pump, its cost for attendance will be greater, both because more men will be required and because they will need to possess a greater degree of skill and intelligence. For the same reasons, and also because of the rapid wear of valves and packings, the probabilities of falling off in duty are greater for the reciprocating unit.

Further, full-load operation 24 hr. per day and 365 days has been assumed—an improbable condition. If the load factor is put at 66.6%, the comparison is still more favorable to the centrifugal pump. The annual fuel costs become $14,690 and $9,690 for the centrifugal and reciprocating units respectively and the annual costs per water horsepower-year become $25.90 and $44.90.

For average operations, therefore, and with fuel prices such as are generally found in the Middle West, a modern steam-turbine-driven centrifugal pump will deliver water at about half the cost for pumping as compared with the highest development of the reciprocating type of pumping engine.

Track Elevation on the Nickel Plate Railroad at Chicago

SYNOPSIS—The piece of work described in this article is peculiar in that conditions necessitated abandoning the original line and building an elevated line on a new location. The line has to rise to cross one railway, then descend to pass under two railways and then rise again to connect with one of the latter. There is a large amount of concrete work for the length of the line, and a notable structure is a steel skew bridge with plate girders of from 125½ to 132 ft. in length.

The track elevation at Grand Crossing, Chicago, includes the elimination of railway crossings of both streets and railways at grade, and has involved special problems for the New York, Chicago & St. Louis Ry. (Nickel Plate), which is one of the four railways concerned. The situation is shown by the sketch plan and profile, Fig. 1.

Originally all the railways were at the street level. The two parallel lines of the Lake Shore & Michigan Southern Ry. (now New York Central Lines) and the Pennsylvania Lines crossed the Illinois Central R.R. at grade, and the New York, Chicago & St. Louis Ry. (parallel with the Illinois Central R.R.) crossed the Pennsylvania Lines at grade (by a 14° curve) to connect with the Lake Shore tracks. To eliminate the street grade crossings the Illinois Central was elevated sufficiently to clear the streets, which were depressed at the intersection, and the parallel lines of the Lake Shore and Pennsylvania were elevated still higher in order to pass over the Illinois Central R.R. Each road has numerous tracks and heavy traffic at this point.

To eliminate the grade crossing of the Nickel Plate with the Pennsylvania Lines, the old connection was abandoned and a new one located as shown on the plan. Beginning at 87th St., this connection rises on a grade

of 0.6% and swings with 10° curves so as to cross over the Illinois Central. It then swings north on a long curve of 1° 36″ and descends at 1% grade to pass under the other two lines in a skew subway (on a 10° curve), and then, running parallel with the latter, it rises on a grade of 0.638% till it is on a level with the Lake Shore

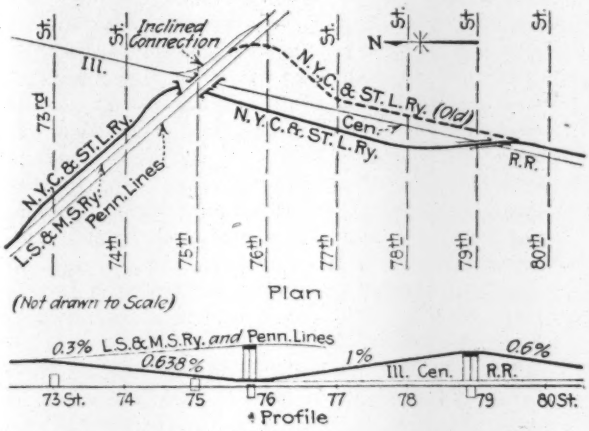

FIG. 1. TRACK ELEVATION AND GRADE-CROSSING ELIMINATION AT GRAND CROSSING (CHICAGO)

Ry., with which it connects a little north of 73rd St. Only two tracks have been built as yet, but the plans provide for four tracks.

The elimination of the Nickel Plate grade crossing in 1909 closed the original connection with the Lake Shore Ry. As the new connection had not been built it was necessary to divert the Nickel Plate trains to some other route, and since November, 1909, they have been detoured from 95th St. over the Rock Island Line, which brings them into the same terminal station (the La Salle Station). The new connection is expected to be put in service by December, 1915. Unlike most of the track-elevation work in Chicago, this line has been built without the complications involved in doing the work while the line is carrying traffic.

Concrete Retaining Walls

From 87th St. the new line is on an ordinary embankment as far as the bridge over the Illinois Central R.R., the fill being made by dumping from a temporary trestle. At the approach to the bridge, however, long retaining walls are required in order to keep the slopes of the fill clear of street lines and property lines on the east side and clear of the Illinois Central R.R. right-of-way on the west side of the tracks. This is shown in Fig. 2, and the sections of walls are given in Fig. 3.

The east wall is 600 ft. long, with a height of about 35 ft. for 200 ft. at the middle, the ends then sloping down on grades of from 12 to 18%. It is built in sections 50 ft. long (with expansion boards at the center of each section), except that at the north end, where the wall is low, there are sections 35 and 45 ft. long. Two layers of tar paper were placed between the sections.

The wall has a vertical face, with no coping, and the back is stepped. It was originally proposed to put a line of concrete piles under the face of the wall, but this was abandoned and the footings were made somewhat deeper, being carried 1 ft. into the solid clay subsoil. The width of base of wall as built is 50% of the height plus 1 ft. The west retaining wall is an extension of the bridge abutment.

West of the Illinois Central R.R. the line is mainly a fill between concrete retaining walls. At 78th St. an incline has to be provided for an industry track on a

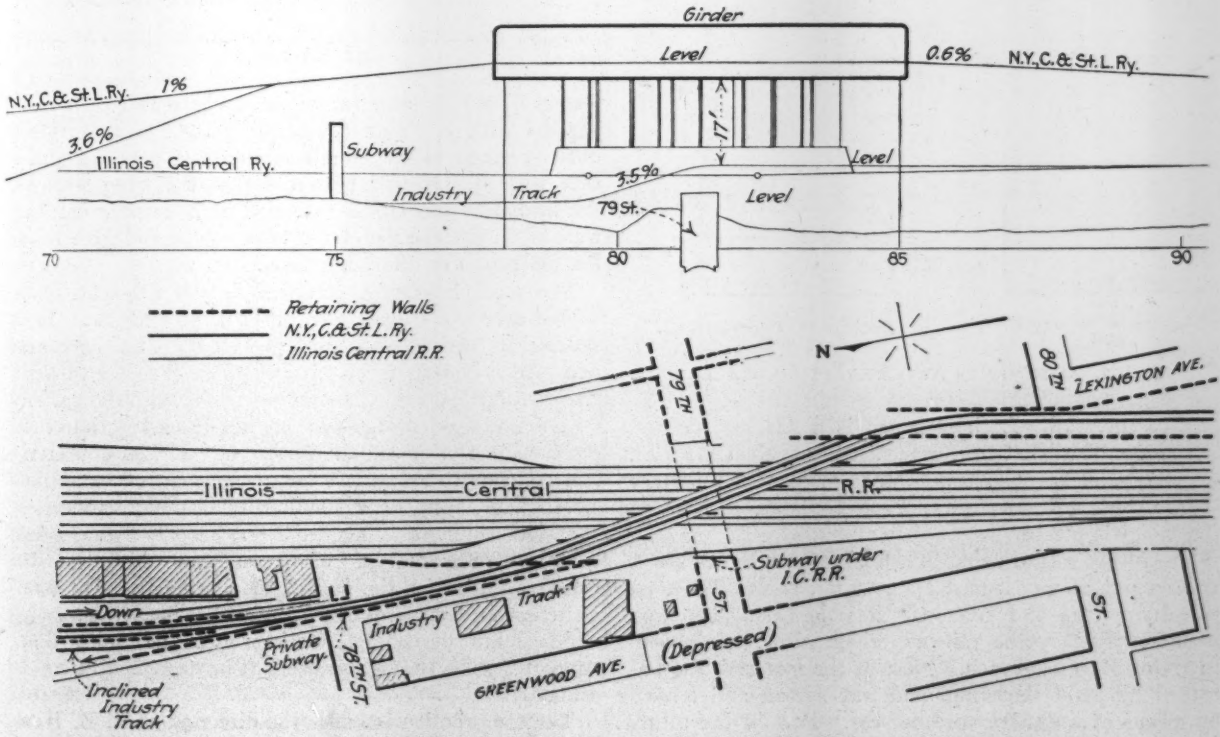

FIG. 2. SKEW CROSSING OF THE NEW YORK, CHICAGO & ST. LOUIS R.R. OVER THE ILLINOIS CENTRAL R.R. AT GRAND COSSING (CHICAGO)

grade of 3.6%, with a subway beneath this to give access to the railway company's property. This necessitates the triple-wall arrangement shown at the left in Fig. 2. At the 79th St. bridge over the Illinois Central R.R. the retaining wall and abutment meet in a sharp angle, as shown on the plan. The sections are given in Fig. 3. Fig. 5 is a view at this angle, with the wall at the left and the bridge abutment on the right. The tie bars are pieces of old rails which anchor the walls together.

All concreting was done by means of a train having a mixer and elevator tower on the first car and material cars behind, as described in *Engineering News*, Aug. 12, 1915. The walls are surmounted by pipe hand railings carried in standards, which are secured to the outer

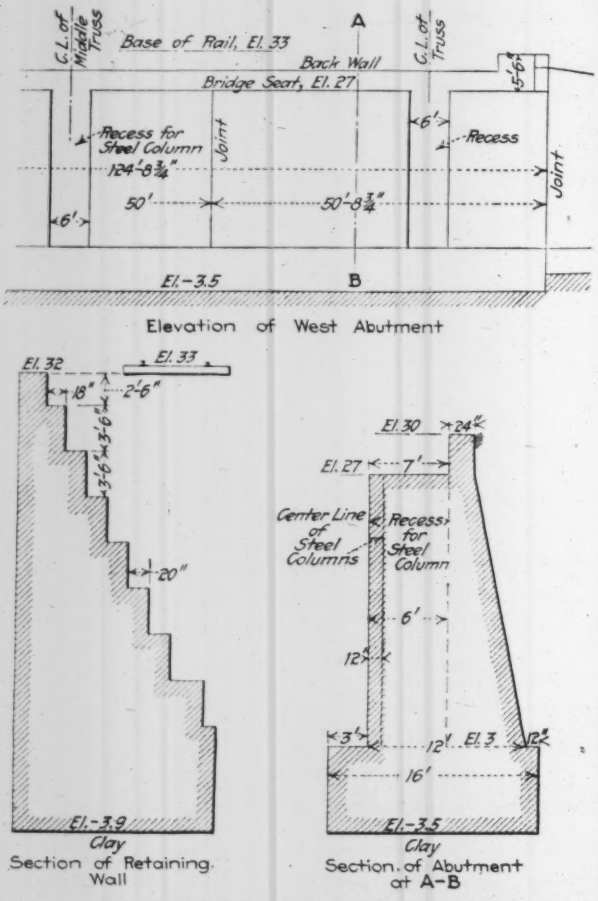

FIG. 3. ABUTMENTS AND RETAINING WALLS

face of the wall. Each standard is a flat bar, twisted at the middle so that the lower part lies against the wall. As the walls have no coping this construction is very simple, but rust streaks occur on the wall as soon as the metal is placed.

The filling was of bank sand hauled from South Gary, Ind., where it was loaded by a 70-ton steam shovel on side-dump cars and side-door gondola cars. The cars were supplied by the railway, which also hauled them in trains of 30 cars each. Most of the material was unloaded by hand shoveling, and was spread and leveled by means of a Jordan spreader car. Part of the filling was deposited from a temporary trestle, but on a considerable part of the work it was necessary to jack up the track as the filling progressed. The work required only about 42,500 cu.yd. of material and was done between July 1 and Aug. 3, 1915.

Bridges and Subways

The private subway at 78th St. is 12 ft. wide and 13 ft. high, with a roof of 15-in. I-beams embedded in a concrete slab, as shown in Fig. 5. The end walls are carried up to hold the fill for the main tracks and wing walls provide for the slope of the fill on the inner side. Streets are crossed by steel bridges having four spans, with bents on the curb lines and in the middle of the roadway. The steelwork of girders and bents is all incased in concrete. The roadway spans have through plate-girders, while the sidewalk spans are of I-beams. Some of the bridges are built as two parallel single-track bridges, with a narrow space between them, giving light in the street. Over the sidewalks this space is covered by concrete slabs. The bridge floor is a concrete slab on transverse I-beams.

The 78th St. crossing is shown in Fig. 6, with three structures. On the higher level is the Lake Shore & Michigan Southern Ry. and on the lower is the Nickel Plate railroad. At the left the latter passes under the

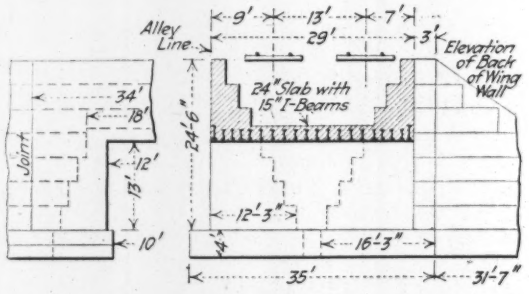

FIG. 4. SMALL SUBWAY UNDER TRACK ELEVATION AT 78TH ST.

former by a long skew subway on a curve and then runs parallel with it on an ascending grade (to the right) until it comes to the same elevation and makes a junction with it. It will be noted that the wing wall of the bridge at the left is extended as a dwarf retaining wall to confine the toe of the upper slope and give room for the tracks on the lower level.

The most important structure is the five-span skew bridge over the Illinois Central R.R. at 79th St. It is notable in having plate girders 125 ft. 6 in. long and one girder 132 ft. long. It has three lines of girders. An unusual feature of the abutments is that the girders do not rest upon bridge seats in the usual way, but each rests upon a steel column in the face of the abutment. This is done to reduce the length of span as far as possible. The abutment was built with rectangular recesses, the steel columns being set later, each on an I-beam grillage on the footing. The recesses will be filled with concrete flush with the face of the abutment. This construction is shown in Figs. 3 and 5. Steel bents with wide columns on concrete footings form the intermediate supports. The superstructure will be described in a separate article.

The construction is under the direction of E. E. Hart, Chief Engineer of the New York, Chicago & St. Louis R.R.; and A. C. Harvey, Assistant Engineer, is in di-

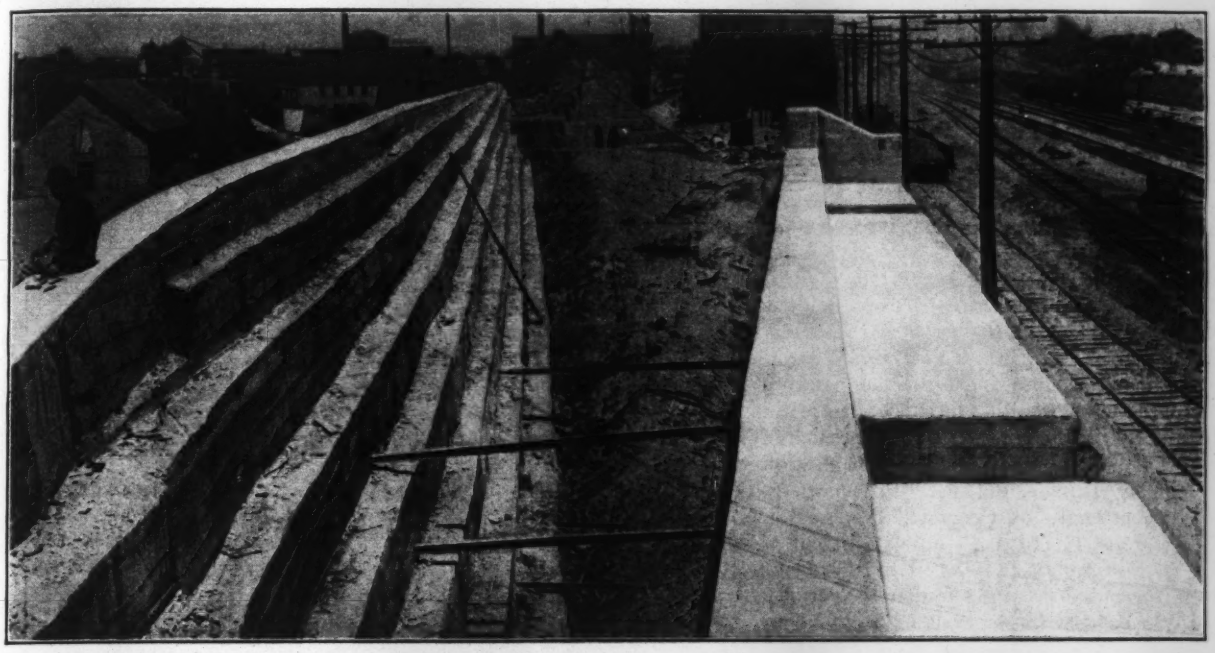

FIG. 5. MASONRY FOR NORTH APPROACH TO THE 79TH ST. BRIDGE AT CHICAGO

The railway comes down from the direction indicated by the concreting tower in the center and swings across the Illinois Central R.R. at the right. At the left is the retaining wall along the alley, which unites with the end of the bridge abutment. The recesses in the face of this abutment are to receive steel columns which support the ends of the bridge girders

rect charge. The Brownell Improvement Co., of Chicago, had the contract for the concrete and P. T. Clifford & Son, of Valparaiso, Ind., had the contract for the filling. The steel street bridges and the bridge over the Illinois Central R.R. were built by the Pennsylvania Steel Co., of Steelton, Pa.

The New York State Barge Canal can be put into complete service in two years, according to a statement in the "Barge Canal Bulletin," the organ of the State Engineer's office. It is stated in the October issue of this journal that "if the referendum of Nov. 2 is approved and if the money can be appropriated soon after the first of next January, it is safe to assert that the Champlain Canal can be completed in one year, as can also the canal between Waterford and Oswego and the branch into Cayuga and Seneca lakes. The balance of the canal through to Buffalo will require one additional year to finish." The statement goes on as follows: "It is not necessary at the present time to enumerate the advantages expected to follow the completion of the canal and its terminals. These benefits have been ably set forth by numerous advocates. However, it may be well to state that there is ample evidence to indicate that transportation men and navigation companies stand ready to make quick use of the canal as soon as the new channel is opened throughout its entire length. Some companies are already organized and are prepared to put fleets in service, chiefly for local traffic, the kind of traffic from which the people of the state will derive most direct and greatest benefit. With wisdom the state decided to add the building of terminals to the canal project. The lack of terminal facilities was one of the greatest faults of the old canal system. In fact, unmonopolized terminals is the crying need of our American waterways today."

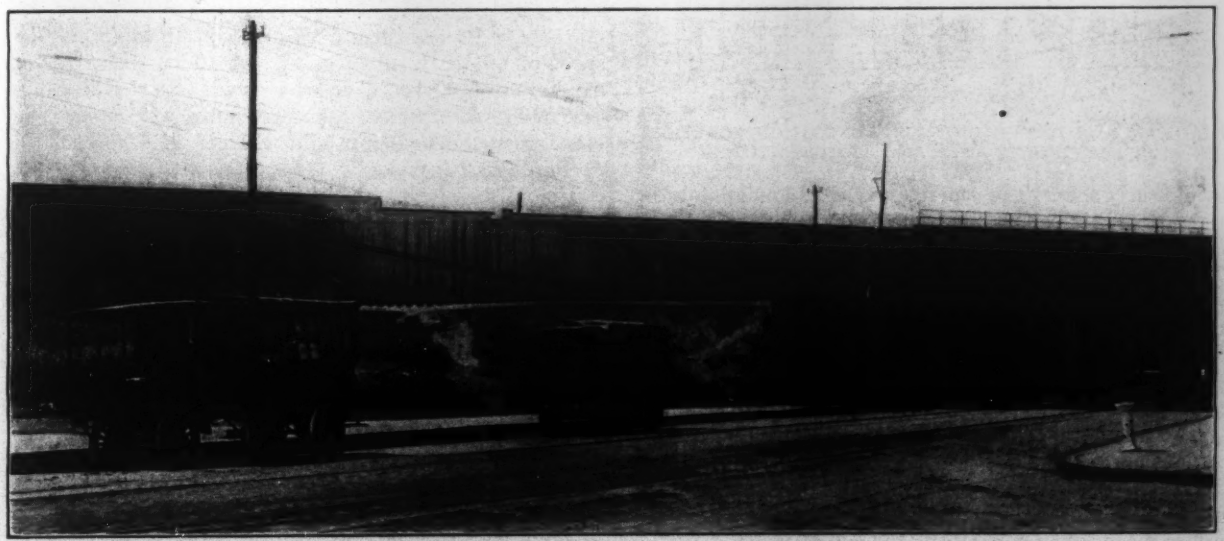

FIG. 6. DOUBLE-DECK TRACK ELEVATION AT 78TH ST., CHICAGO (GRAND CROSSING)

The upper line is the Lake Shore & Michigan Southern Ry. The New York, Chicago & St. Louis R.R. crosses under it by a long skew subway and then runs parallel with it on an ascending grade until at 73rd St. it reaches the same level and makes a junction with the Lake Shore R.R.

Field and Office

Temperature Influence on Set of Concrete

As a result of a series of tests conducted under his direction at the University of Illinois, Prof. A. B. McDaniel has prepared a diagram giving the relation of strength of concrete to external temperature for different ages. This diagram is reproduced herewith. It is taken, together with the other data in this article, from Bulletin 81 of the Engineering Experiment Station of the University of Illinois, entitled "Influence of Temperature on the Strength of Concrete," by A. B. McDaniel.

The tests included 45 on 6x6-in. concrete cylinders, 51 on 6-in. cubes and 60 on 8x16-in. cylinders. They were all made in compression and at periods varying from 3 to 28 days, with intervals of 3 days between the tests

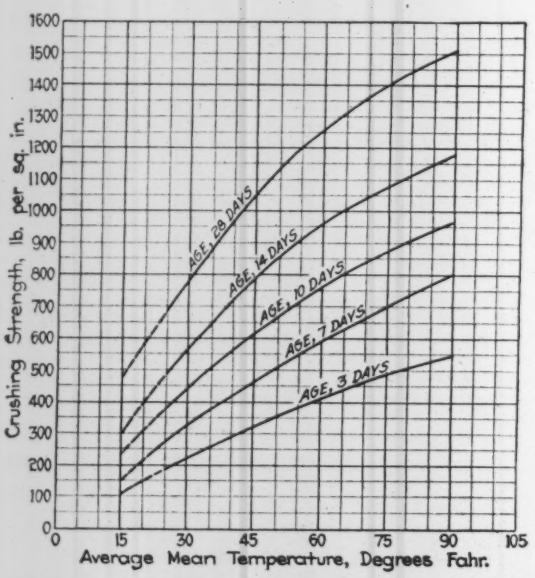

DIAGRAM FOR DETERMINING STRENGTH OF CONCRETE AT DIFFERENT AGES AND TEMPERATURES

at the early ages. The concrete was a 1:2:4 mixture by weight, or 1:2.2:3.6 by volume, of cement sand and crushed limestone. All of the specimens were molded at 70° F., but they were stored in temperatures varying from a mean of 25° F. to 95° F. For the most part they were tested within one hour after being removed from storage. The first series, however, was kept 20 hr. at 70° F., which slightly raised the compression strength of those specimens which had been stored at a lower temperature.

The diagram is an ideal one, made up from the various curves of the large cylinder specimens. Professor McDaniel says that it may be employed to determine the strength which the concrete attained at different stages under a constant temperature, the age at which a particular strength was gained under different temperatures and the strength which may be expected at different ages under different temperatures. The relative strength attained by concrete at different temperatures during hardening and at different ages may be expected to vary somewhat with differences in cement, aggregate and consistency; but it is thought that the values in the figure may be taken to represent the effect upon strength of the variation in the temperatures during hardening.

One noteworthy observation in the tests was that one series which was subjected to temperatures varying below and above freezing so badly disintegrated as to have very little compression strength. Another notable fact which differs somewhat from previous experience was that in some of the tests under a temperature slightly below freezing the concrete gained strength continuously, which explains why the curves in the diagram descend below the freezing point.

Building Invert of Milwaukee Intake Tunnel

By Lee G. Warren*

Concreting the invert of the new Linwood Ave. intake tunnel for the water-supply system of Milwaukee, Wis., is of particular interest from the fact that this operation followed the completion of the arch and side walls.[1] In driving the main part of the tunnel the excavation was carried down only to the bottom of the side-wall section, as shown in the lower section at the left of the accompanying drawing. This left about 0.70 cu.yd. per lin.ft. of tunnel to be removed in advance of the concreting of the invert. The material is Hamilton shale.

Excavation Method and Progress

The floor excavation was done by a night crew consisting of a foreman, 1 drill runner, 1 drill helper, 24 muckers and 4 teamsters. This crew attained an average speed of 60 lin.ft. or 42 cu.yd. per 10-hr. shift, with a maximum of 92 lin.ft. or 64.4 cu.yd. Steel side-dump cars of ⅔-yd. capacity, drawn by mules, were used. The blasting was done with light charges of 60% gelatin dynamite in 2-ft. holes.

The finished invert consisted of 1:2:4 concrete having a minimum thickness of 18 in. and a minimum length of arc of 10.07 ft. It averaged 0.62 cu.yd. of concrete per lin.ft., an excess of 0.05 yd. per lin.ft. over the plan quantity, due to the fact that the excavation had a horizontal bottom. Reinforcement consisted of ¾-in. round steel rods placed 12 in. c. to c. transversely and 15 in. longitudinally. The transverse rods were tied to the rods in the side walls, projecting 18 in. below the bottom of the walls. In placing the side-wall reinforcement the rods had been driven down 18 in. into the shale bottom, and upon excavating for the invert these projections were exposed.

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*Resident Engineer, Linwood Ave. intake tunnel, Milwaukee, Wis.

[1]Previous articles on this 12-ft. tunnel extending 4,000 ft. under Lake Michigan will be found in "Engineering News," of June 18 and Oct. 29, 1914, and Apr. 8 and June 3, 1915.

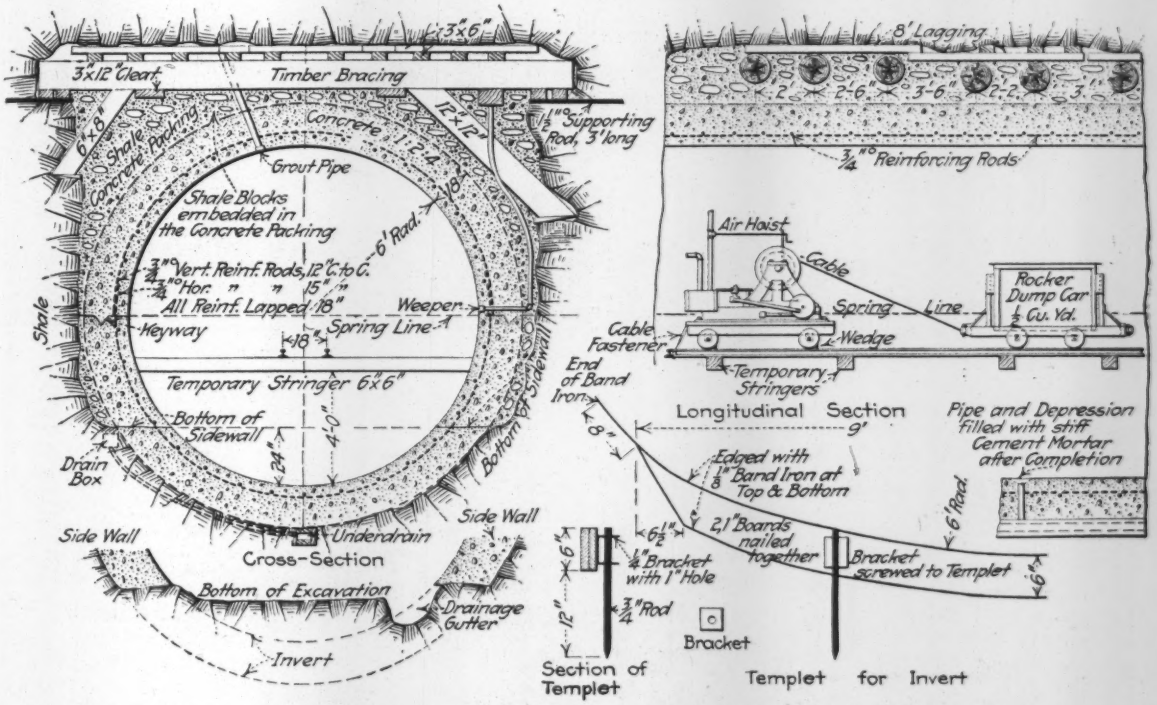
A crew of 18 men placed the invert concrete—6 laborers helped to handle the cars, 6 shoveled the concrete after it was dumped from the cars and 2 laborers tamped the concrete; 2 finishers, 1 foreman and 1 hoisting engineman completed the crew. Two of the shovelers placed the rods and set the templets. The concrete cars were hauled by mules to within 40 ft. of the work and were then hauled by a hoisting engine operated by compressed air. The track was supported over the work on 6x6-in. timbers, 10 ft. c. to c., resting on or against the side walls. This arrangement gave an opportunity to dump the concrete from cars directly into place, as shown.

Concrete Tamped Continuously

Previous to placing the concrete the bottom of the side walls was thoroughly cleaned with small hand picks to remove the pieces of shale. This bottom was then cleaned by two applications of a compressed-air blast at 70-lb. on the templets. The operation of these templets was found satisfactory by the engineers and the contractor's forces.

The progress attained in placing the concrete equaled the invert excavation progress; in fact, the latter retarded the concrete work. A 1-in. finishing coat of 1 : 1 portland cement mortar was placed upon the completed concrete at the end of the day's operations. During the following night shift the two finishers brought this to the proper curve of the invert.

A wooden box drain of 2x8-in. planks, giving an open area of 8 sq.in., was laid the entire length of the tunnel. This drain emptied into sumps, from which air-operated pumps pumped the water to the large sump at the shore shaft, large enough to care for all water encountered. At intervals of 50 ft., 2-in. galvanized pipes were placed, leading from the invert surface to the drain. These carried off all water collecting upon the finished invert



CONSTRUCTION OF THE INVERT OF THE LINWOOD AVE. INTAKE TUNNEL; MILWAUKEE, WIS.

pressure, which completely removed all dirt and mud. The side-wall bottom was then painted twice with 1 : 1 cement mortar. The invert concrete was placed in two layers—the lower one being 12 in. thick and the upper one 6 in. The reinforcement was placed between the two layers. The two laborers never ceased tamping the concrete, one operating on each side. Great care was taken thoroughly to tamp this concrete below the side walls. After placing the concrete, a 1-in. finish of 1 : 2 cement mortar was applied.

The only forms used for the invert were wooden templets, which are shown in the drawing. They were set by the inspectors as soon as 12-in. depth of concrete was laid. They set the templets every 25 ft. by measuring down from grade marks in the concrete arch. The templets were held in position by means of three ¾-in. steel pins about 18 in. long, each held by two eye-bolts and prevented injury to the fresh concrete. After the completion of the entire length of invert these pipes were filled with 1 : 1 mortar.

Invert Proves Solid; No Settlement

Three months have elapsed since the completion of the entire invert and no cracks or settlements have developed. Before starting the work it was thought there might be some danger of the invert concrete settling and separating from the bottom of the side-wall concrete, thereby breaking the bond. However, the careful tamping of the invert concrete beneath and against the side walls undoubtedly prevented this separation.

This tunnel is being constructed by Joseph Hanreddy, of Chicago, Ill., under the direction of George F. Staal, City Engineer. The writer is resident engineer of construction.

Barney Incline for Hauling Wagons Out of Pit

The views herewith show a barney incline rigged up in the foundation pit for a new loft building at 24th St. and Broadway, New York City, by the Thompson-Starrett Co., builder, for hauling the dirt wagons up to street level. The arrangement is simple, enables wagons to take a full load, avoids the use of snatch teams and is much more convenient than any other arrangement of hauling line. It is not strictly new, but in New York City it is an innovation in building practice. A. G. Moulton, superintendent for the builder, is responsible for using it in this case.

The barney car runs on a narrow-gage track of light rails laid on the incline. The nose of the car comes above the level of the rear axle of the wagon and thus when placed behind the axle pushes the wagon up the slope. A cable from the front of the car goes up the incline to a snatch block near the top, where it passes through the decking and laterally downward to a hoisting engine.

The car, as will be noted in the view in Fig. 1, is quite heavily made, and the butting block is well braced back to the main frame.

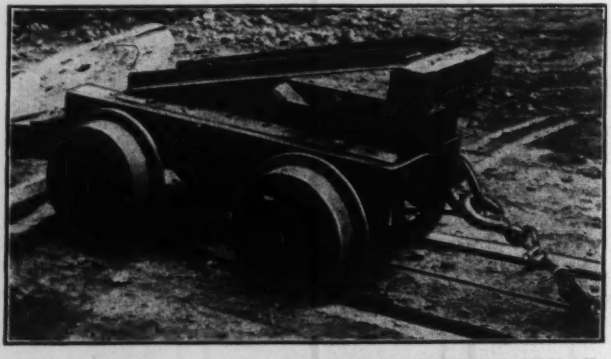


FIG. 1. BARNEY FOR HAULING DIRT WAGONS OUT OF FOUNDATION PIT

Railway-Valuation Office Index and File System

By H. J. Saunders*

In the work of the Pacific District of the Division of Valuation, Interstate Commerce Commission,[1] it was early realized that for filing the mass of notes and other accumulated material some system must be found which would be practically self-indexing and would allow for unlimited expansion. The Pacific District, with headquarters at San Francisco, includes some 300 railroads, covering 15 Western States. Further, it was found that the notes for the first 1,000 mi. of roadway alone occupied eight 12x24-in. filing drawers. Multiply this by 50 (50,000 being the approximate total mileage in the district) and one can begin to appreciate the problem presented.

FIG. 2. THOMPSON-STARRETT CO.'S BARNEY IN POSITION FOR HAULING A LOADED WAGON UP THE INCLINE

The actual inventory work is divided among the several district departments—roadway, structural, mechanical, telephone and telegraph, and land. The Roadway Department, having the largest force in the field, and accumulating the most material, is the only department that will be described here.

The notes which are taken and computed by the field parties are forwarded to the district office for final checking and compilation. They are bound into volumes, having heavy manila covers marked as indicated in Fig. 1. After receipt in San Francisco they are divided into convenient size for handling and are filed in 12x24-in. steel filing drawers, 42 to a section. In these drawers the various classes of notes, such as "cross-section," "track," etc., are separated by brown letter-size folders with heavy blue guide cards (one-third cut) separating the valuation sections.

Maps, profiles and plans are forwarded by the field parties with the notes, and after being marked by the

*731 Wells Fargo Building, San Francisco.

[1]The work of the Division of Valuation of the Interstate Commerce Commission was described quite fully by George H. Burgess in "Engineering News" of July 1, 1915.

district office filing clerk with their appropriate file number are card-indexed and filed in pigeonholes, which were found to be much more accessible than drawers. Maps and profiles are rolled and plans are folded.

A decimal system of indexing was adopted, the following primary numbers being selected to distinguish the different classes of material and the correspondence regarding the same:

420 Field Notes.
430 Maps.
440 Profiles.
450 Plans.

Immediately following one of the above-cited numbers is the number designating the carrier, after which is added a number showing kind or account. Thus the file number 420.3 M 03.2 would indicate field notes (420), Great Northern Railway (3), Montana Valuation Section (M 03), cross-section notes (2). If the last figure had been 1, it would have indicated track notes; 3, structure notes; 4, assistant engineer's notes; 5, platted cross-sections; and 6, general data or correspondence regarding some particular point in the inventory.

File number 430.3 M 03.2 would indicate map (430), Great Northern Railway (3), Montana Valuation Section (M 03), station (2). If the last figure had been 1, it would have indicated alignment; 3, miscellaneous. The last figure indicates in every case the account number in the Interstate Commerce Commission classification to which the item in question is chargeable.

Each book of field notes after being indexed as indicated above has then but one place for filing—the drawer for the carrier concerned, which is divided into valuation sections and each section subdivided as to kind of notes.

Maps, profiles and plans after being marked are card-indexed as shown in Fig. 2. The serial number is placed on each print, so that it can be conveniently picked out from the pigeonhole containing other prints of that file number. This card index is on 3x5-in. white cards, blue guide cards one-half cut being used to distinguish different carriers, and salmon guide cards one-third cut being used to distinguish valuation sections of each carrier.

Before any carrier's notes are considered in the district office all notes are thoroughly gone over, a general scheme of instructions prepared, table of weights of track material compiled and other standard data worked up. The work of assembling the data by accounts on the Commission's 11x17-in. assembly forms is then begun, each computer having his special work outlined in advance and the work proceeding in a systematic manner, as many helps as possible, such as computing machines, diagrams, tables and slide rules, being used. A record of all computing work done in the district office is retained on the form shown in Fig. 3, which is used as the back cover of each book.

The computers enter certain data obtained from the notes in other card-index files, among which is the joint-ownership file shown by Fig. 4. Filing one of these cards under each carrier concerned will doubtless be the means of avoiding a large amount of duplication. Another is the abandoned-property file, which is made on

Carrier
Val. Sec.
Kind of Notes
Mile Post _____ to Mile Post ____
Station _____ to Station _____
Party No.__ _____
Engr in Charge
Fig. 1 _____, 191_

	STATION NAME	Serial No.
	Linne	1112
	Stockton	1113
	Stockton City	1118
	Hayward	1134
	Trevarno	1135
	Goeckem	1137
	Ludvig	1138
	Midway	1139
	Sunol	1140
Fig. 2	Ortega	1141

RECORD OF COMPUTATIONS.

CARRIER NO.....VAL. SECT. NO.....

M.P.....to M.P.....STA.....to STA.....

Name of Computer	Class of Work	Date From	Date To	Miles	Hours	Hours Per Mile	Remarks

Fig. 3

	S.P. L.A. & S.L. R.R. CO.	1
Acct. #10	Los Angeles Yard, Calif. Mi.3 South (So.Pac.Ry.Conn.)	420-1-031
	R.R.Crossing (Track #225-Sta.45+05.2)	P.239 A
	Tr. #225 and Jt. Tr. #261	
	S.P. L.A. & S.L. R.R. Co. 50%	(420-16-Kings
	Southern Pacific R.R. Co. 50%	P.10

Fig. 4

Form No. P-26
4-9-15

INTERSTATE COMMERCE COMMISSION
DIVISION OF VALUATION
PACIFIC DISTRICT

Date
Carrier
Val. Sec.

Compiled by
Checked by

ABANDONED PROPERTY

Acct. No.	File No., Page, Etc.	Detailed Description	Unit	Total Quantity

Fig. 5

Acct.No.	S.P.L.A.& S.L.R.R.CO. VAL.SEC. NO. 2	420-1-01e
3-11	Lowering Grade on California St., Long Beach	
	Necessitated by City Ordinance. Work done in 1905.	
	Actual charges to Acct. #317.	
	Royalty on 1677 Cu.Yds. Gravel - Amt. not given.	
	Company labor @$170.44	
	(This Revision included in excavation)	
	7-2a-15 Compiled by H.O.M.	69

Fig. 6

FROM \ TO	CALIFORNIA	730-9 Serial No.
Utah	Class and Commodity Rates (S.W.L.A.)	9
"	Cement (U.S.L.3369 A. S.L.R. 344 B)	20
"	Lumber (S.L.R. No.91 B)	20
Oregon Washington California	Lumber (S.F.Co.No.47. F)	9
Utah Nevada	General Commodities (S.L.R.135 C)	20

Fig. 7

RAILWAY VALUATION OFFICE-INDEX AND FILE CARDS

Fig. 1—Field-book cover marking. Fig. 2—Index to station maps. Fig. 3—Computation record. Fig. 4—Joint-ownership file card. Fig. 5—Abandoned-property file sheet. Fig. 6—Carrier-claim file card. Fig. 7—Freight-tariff index card

letter-size sheets, as shown in Fig. 5. These are filed in regular 12x24-in. file drawers by carriers and subdivided by accounts. A carrier's-claim file is made on 3x5-in. white cards subdivided by suitable guides into carriers, states and valuation sections. This file shows a convenient record of items regarding which there has been no final agreement between the Government and the carrier's engineers. A sample from this file is shown in Fig. 6.

A card file on 3x5-in. white cards is maintained to show the general file number assigned to each carrier, filed alphabetically. The corporate name is given in full, with the mileage of main track, date of inventory and other general information.

A complete file of freight tariffs is maintained for use in figuring freight on all articles inventoried in this district. These are card-indexed as shown in Fig. 7, the cards being divided by suitable guides into states and carriers.

The foregoing system of indexing and filing seems to be flexible enough, so that there will be no danger of its becoming burdensome, and at the same time it is capable of almost unlimited expansion.

For the Pacific District R. A. Thompson is member of the Engineering Board; M. P. Paret is District Engineer; C. H. Byers is Assistant District Engineer and the writer is Office Engineer.

Connecting Cast-Iron Pipe Sections Under Water

A new 36-in. cast-iron water-works intake has been laid at Quincy, Ill., to replace a 30-in. wood-stave pipe line. The new intake is 1,823 ft. long, the individual pipes being of the bell-and-spigot type. The initial operation in the actual laying of the pipe was to place four 12-ft. lengths on skids, parallel to the shore line. The lengths were connected together by ordinary lead joints calked by pneumatic hammer. These 48-ft. sections were made up with a 6-in. bell forward and a machined spigot at the rear end. A bead had been cast on the pipe 18 in. from the special spigot.

The lead joint was poured into the 6-in. bell around a cast-iron form turned to the exact shape and size of the machined spigot. After the lead had set, the form was removed. Heavy steel clamps were then bolted around the pipe back of the forward bell and around the bead.

When a section was to be taken out for laying, a large scow was anchored with the A-frame derrick over the section to be hoisted (see Fig. 2). Two hitches were taken around the side of the pipe, which was hoisted off the skids; the scow was then pushed out to an anchorage over the site. The pipe was carried above the water as shown in Fig. 1.

When the trench had been reached the section was lowered and with the help of a diver the spigot end was led into the bell of the preceding section. Bolts were passed through the clamps (which had already been bolted around the bell and spigot), and by tightening the nuts on the bolts, the spigot was forced as deeply as possible into the cold lead in the bell. The diver then calked the lead around the pipe with a pneumatic hammer. All the clamps and bolts were left on the pipe

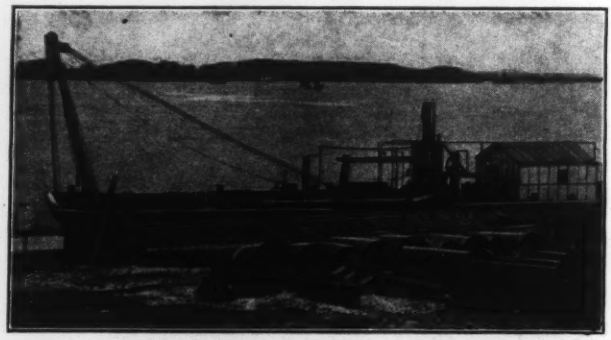


FIG. 2. PIPE SECTIONS MADE UP ON SHORE AND AWAITING TRANSPORTATION

to strengthen it. No backfilling had to be done, as the sand drifted into the trench very rapidly, and within a few hours the pipe was entirely covered.

The new intake was designed by W. R. Gelston, Superintendent of the Citizens Water-Works Co., who also supervised the construction. The contractor was Joseph G. Falcon, of Evanston, Ill.

New Theory for Long Life of Cast-Iron Pipe

A new explanation for the claimed longer life of buried cast-iron pipe over rolled steel or iron pipe was given in a paper presented before the last annual meeting of the American Foundrymen's Association by R. C. McWane

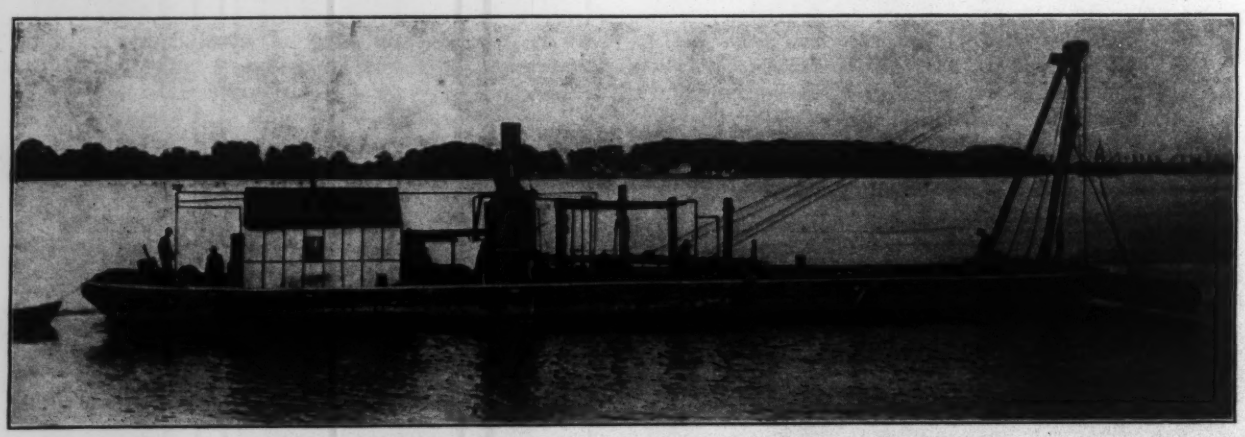


FIG. 1. TRANSPORTING 48-FT. PIPE SECTION TO SUBMARINE TRENCH

and H. Y. Carson, of New York. The initial rusting of cast iron is pictured as taking place rapidly, owing to the impurities in it like phosphorus, sulphur, silicon, etc. But the rusting soon stops, since the undisturbed crystals are held together at one or more points by metallic bonds and the surface rusting is so intermeshed with the irregular aggregations of crystals that the force exerted by absorbed moisture is not sufficient to separate the crystals and the oxide. The rust therefore remains as a protective coating. Rolled metals, on the other hand, are pictured as having their original structure destroyed and as consisting of a series of laminations and leaves which are easily dislodged when rusted.

Novel Method of Draining a Swamp for an Earth Fill

That part of Delaware through which the Coleman du Pont Road is now building, between Georgetown and Selbyville, is level and for the most part free from swamp lands. Although the specifications required all swamps to be drained and excavated to solid foundation, it was thought inadvisable, on account of expense, to do this in all cases. In one instance a swamp was reached which consisted of a network of roots and shrubs about 2 ft. in thickness, floating on about 4 ft. of muck of a semi-liquid consistency. Below this was solid foundation of a sandy-clay nature. The grade of the road required about a 6-ft. fill over the swamp, and it was decided that so heavy a fill would soon seek a solid foundation.

When the fill was partly completed it was noticed that it did not settle as much as was expected, but was floating on the network of roots and shrubs that constituted the surface of the swamp. A method of overcoming this was suggested when a stump was blown. The hole left by the uprooted stump extended through the network of roots into the muck. The muck floated up through the hole, being pushed out by the weight of the fill. Following this observation many holes were dug through the network of roots, which allowed the underlying muck to escape and permitted the fill to settle to good foundation. The holes were dug in each case parallel to the fill and about 3 ft. from its toe. About $1,500 was saved by this method, according to Charles M. Upham, Chief Engineer of the Coleman du Pont Road, Inc., Georgetown, Del.

BUILDING THE FILL WHICH REMAINED UNSTABLE UNTIL DRAINED BY SUMP HOLES

New Iron-Cobalt Alloy Shows Promising Properties

Studies of an iron-cobalt alloy, formula Fe_2Co, made by T. D. Yensen at the Engineering Experiment Station of the University of Illinois, have shown magnetic properties of great promise in electrical design. The iron was of a double-refined electrolytic product and the alloy was melted in a vacuum furnace. Impurities did not rise above 0.03%.

The saturation value of magnetization was found to be 13% higher than that of pure iron. Moreover, its permeability in medium-strength magnetic fields is 25% higher than for pure iron or commercial grades of iron. Its hysteresis loss in medium high densities is considerably less than for the best grade of commercial transformer iron. At maximum densities the hysteresis loss is about the same as for commercial iron. The specific electrical resistance is about that of pure iron.

Mechanically the alloy is brittle, but fairly strong. In the forged state the alloy is over twice as strong as pure iron, but when annealed the ultimate strengths of the alloy and of the pure iron are about the same.

The high cost of cobalt at the present time prohibits the wide use of such an alloy, but if the price of cobalt should drop, the alloy might find use in parts of electrical machinery where the magnetic density is necessarily high.

such as the armature teeth of motors and generators. It is expected that the electrical resistance, now low, can be raised by the addition of other alloying metals. This would reduce the eddy-current losses.

NOTES

A 240-Ft. Plate-Girder Swing-Bridge — A remarkable swing-bridge was completed a few months ago on the Canadian Pacific, where its "Short Line" crosses the Lachine Canal at Caughnawaga, near Montreal. It was built in phenomenally short time—Dec. 1, 1914, to June, 1915. The crossing is double-track, and four girders are used. Their length is 239 ft. 7 in. and their depth 13 ft. 6½ in. over the pivot pier and 8 ft. at the ends. The girders weigh 112 tons each; the whole swing-span weighs 615 tons. The photograph shows the swing-bridge and a 90-ft. span on the south bank of the canal for a future railway crossing.

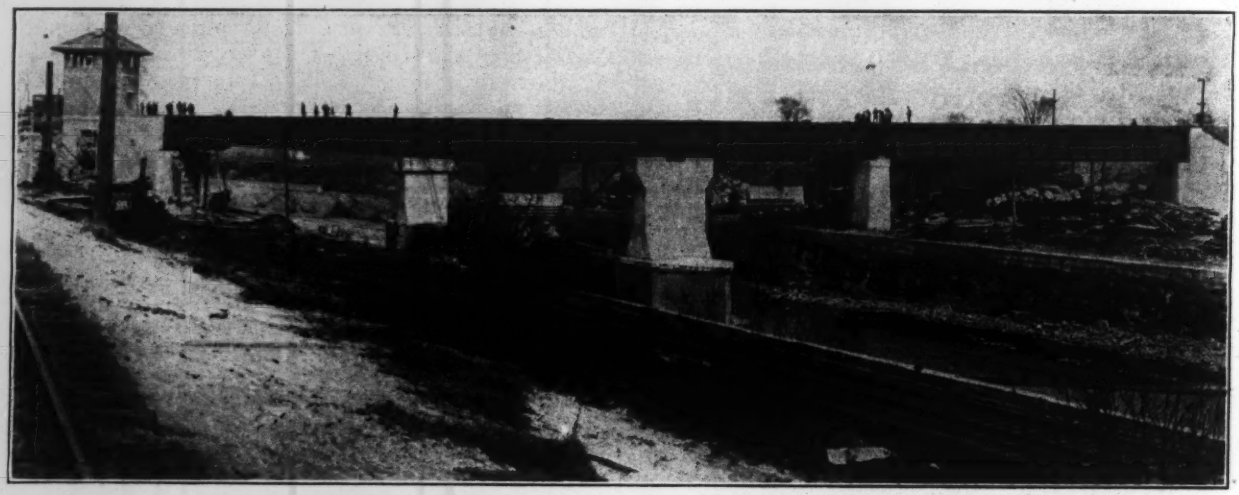
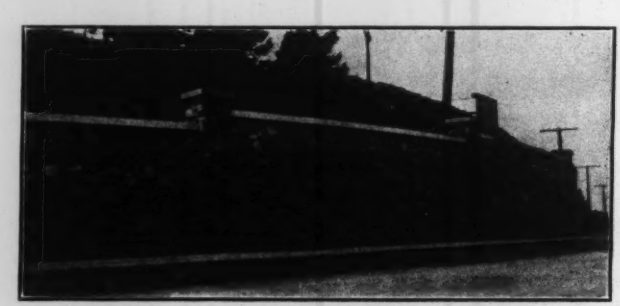


PLATE-GIRDER SWING-BRIDGE OVER LACHINE CANAL, 240 FT. LONG

Why Some Retaining Walls Fail—The picture shows a retaining wall holding a bank in front of a California suburban residence. It is claimed by some to be a model of beauty in cobblestone walls. Its dimensions, however, are more interesting than its beauty. The wall is reported as being about 400 ft. long and from 2 to 12 ft. high. Its thickness at the top is 12 in. and at the base 24 in. There is a footing 3 ft. wide under the wall. The face of the wall is formed into pilasters at intervals, but these have only an architectural effect and their buttress function is negligible.



TWELVE-FOOT COBBLE RETAINING WALL, ONLY 24 IN. THICK AT BASE

In spite of the fact that the proportioning of the wall violates all rules and principles as to thickness, it is still standing and will probably continue to stand so long as the earth behind it remains fairly dry and coherent. The wall is said to have cost $1,400 to build, but the owner got the cobbles and the sand for the cost of hauling them 2 mi.

Tunneling With Canary Birds No Cruelty—Use of canaries to test the condition of the air in the West Side tunnel, far beneath the bed of Lake E..e, in which scores of men are working, is not a violation of the law prohibiting unnecessary cruelty to animals, in the opinion of Cheney C. Jones, general agent of the Cleveland Humane Society. G. C. Van Duzen, superintendent of construction, said yesterday that the birds, kept in a cage in the tunnel office, spend but one-half hour each day in the tunnel.—From the Cleveland "Plain Dealer," Oct. 21, 1915.

To Prevent Washouts on Roads in Maryland low concrete barriers are built diagonally through the shoulder, from edge of road to ditch. These are constructed flush with the shoulder, and on 5 to 6% grades and medium soil are spaced 25 to 30 ft. apart. On steeper grades the spacing would be closer. The Maryland "breakers" are 12 in. wide by 18 in. deep. Where the shoulders are kept in repair the "breakers" do not obstruct travel.

Cost of Ditching by Dynamite—Two interesting cases are noted in the November issue of the Du Pont powder company's house organ. A large contract for ditching by dynamite was recently executed by L. W. Acheson, of Salem, Ore., at a contract price of $1.41½ per rod where the right-of-way was cleared. Holes for a 4x3½-ft. ditch were spaced 18 in. apart and were 18 in. deep, except where stumps and matted roots prevented. In each hole one-half stick (¼ lb.) of 60% dynamite was used. In the holes of small depth heavier charges were employed. About 6,000 lb. of explosive was used. Three electric blasting caps were placed at intervals in each 150-ft. section. A crew of four men blasted a maximum of 1,800 ft. of ditch in 8 hr. Working through an open swamp, 600 ft. was blasted out in 2 hr. In the second case a ditch 12 ft. wide, 4 ft. deep and about 400 ft. long was recently blasted across a mud flat at Carney's Point, N. J., by A. E. Anderson. Three rows of holes, 4 ft. apart, were put down along the line of the ditch. The holes were made with a shovel handle and were 18 in. apart in the row and 3 to 4 ft. deep. Each hole was loaded with two cartridges of 60% dynamite—one at the bottom and one 15 to 18 in. down from the top. In the middle row for part of the line two cartridges were put on the bottom and a third was placed at the top. The charges were primed with No. 8 blasting caps every 15 ft. The cost covered 800 lb. of dynamite, $120; exploders, 50c.; labor of four men for one day, $8—total, $128.50.

The Strength of Bridge Stringers as affected by creosoting has been the subject of tests made under the direction of the Forest Service, United States Department of Agriculture (Bulletin 286, Sept. 27, 1915). The woods used were loblolly pine, longleaf pine and Douglas fir. The treatment was of two kinds—boiling and steaming. The following deductions were reached: (1) Timber may be very materially weakened by preservative treatment, but creosote in itself does not appear to injure it. (2) Treatment which will seriously injure one timber may have little or no influence on the strength of another, and the same treatment may have different effects upon different pieces of the same species. (3) Comparisons should not be made of the effect of a preservative process upon timbers of different species.

Editorials

Brick and Stone Pavements on Mortar Beds

A live subject of discussion at the recent Dayton convention of the American Society of Municipal Improvement was the desirability of mortar beds or monolithic construction for brick pavements. The question of adopting standard specifications covering the use of mortar beds for stone-block and brick pavements was thoroughly investigated by the subcommittees on these types of pavement, and in each instance the conclusion was reached that this method of construction had not yet got beyond the experimental stage and that the society should not yet approve it. This seems to justify—if justification is necessary—the attitude taken by *Engineering News* in the editorial of Aug. 5, 1915.

Emphasis was placed on the fact that the monolithic method of constructing brick and stone-block pavements is an experiment; and the point of view taken by this journal in this and in similar instances is that any departure in practice from that which has been long established should be thoroughly tested before it is adopted, especially if the established methods have given and can give satisfactory results, and that the success of the mortar bed or the monolithic method of construction remains to be demonstrated. This is precisely the attitude taken by the subcommittees of the American Society of Municipal Improvements, which was approved by the society as a whole.

From the various opinions publicly expressed at the meeting and from conversations with various engineers there seems to be little question that so far the experience with the new monolithic pavements has been satisfactory, and *Engineering News* is very glad to record that fact. There were, however, other points brought out in these conversations which are noteworthy in this connection. They are as follows: While it is true that there is often a small air space between the sand cushion and the brick surface the reason is easily explained. The sand cushion must be thoroughly compacted, and it is practically impossible to compact clean dry sand by rolling. It does compact some under the vibration of traffic after the pavement is completed—hence the objection that has been raised to sand cushions. (It was generally agreed that the talk about the sand flowing out from under the pavement is tommy-rot.) If sand is not perfectly clean, if it has a little clay or loam added, it will compress and form a compact cushion much more easily; and the same end may sometimes be accomplished by slightly dampening the sand while rolling, which causes adhesion of the particles. When these details are properly looked after, it was generally conceded just as good brick pavements could be laid on a sand cushion as on a mortar bed.

On the other hand, it seems certain that the omission of the bedding course entirely, as practiced by W. T. Blackburn of the Dunn-Wire-Cut-Lock Brick Co. at Paris, Ill., has great advantages in eliminating construction hazards. There are some possible disadvantages, however, which remain to be disproved. It has been suggested that a monolithic pavement half brick and half concrete, having different rates of expansion, top and bottom, because of the difference in materials, may develop cracks from internal stress. Moreover, when the subsurface conditions are such as to cause cracks in the concrete base, these cracks will probably extend through the brick wearing surface, if this is made monolithic with the base, where the wearing surface might otherwise have been kept intact.

Sewage Treatment and the War

Among the numerous vagaries of the European War, two that are of particular interest to the sanitary engineer may be mentioned. One is that the Royal Commission on Sewage Disposal went out of existence some months ago, without much likelihood that its 17 years of work will ever amount to much beyond the amassing and digesting of data and the early loosening of the shackles of the Local Government Board. The restrictions of this body bound every municipality to the land treatment of sewage, regardless of local conditions against it and of all such advances as the septic tank, contact bed and sprinkling filter as have been made up to about 1900. It is a pity that the other conclusions of the Commission, most of which need Parliamentary action to become effective, are not likely to be acted upon for some time to come, if ever.

The other vagary is that, according to reports from friends of Dr. Karl Imhoff, abroad and here, a large number of Imhoff tanks have been built in the conquered portions of Belgium and France. It may also be mentioned that conditions seem to have been ripe when the war broke out for the voluntary building of a number of Imhoff tanks in England, but these and presumably more rapid progress with activated sludge on a considerably greater scale than has yet taken place have been held up in Great Britain by the war. Meanwhile the use of the Imhoff tank has been spreading on every hand in the United States and Canada, and activated-sludge experiments, some on a large working scale, are being carried on with great zeal and promising results in America.

When the war is over and ordinary municipal activities have been restored throughout Europe there may be some surprising realignment of sewage treatment. Necessary economies will force all the European countries engaged in the war to adopt a rational rather than an ideal sewage-treatment policy, such as has been practiced in Germany for a decade or two. Partial processes, like screening and tank treatment, will doubtless be widely employed, and in many instances nothing more may be feasible for years to come. If the activated-sludge process is shown to be an economic success it bids fair to be adaptable to almost any degree of treatment and thus to find its way to all parts of the world. By the time the war is over, the possibilities of this most interesting and promising method of sewage treatment will probably be determined.

Track Maintenance on Heavy Electric Railways

The problem of the proper relation of the railway track to the equipment and traffic which it carries seems to be developing on interurban electric railways in somewhat the same way as it has developed on steam railways. That is to say, the track construction is often light in relation to the traffic, and the strengthening of the track lags behind the increase in weight and wheel-loads of electric cars and locomotives. Track maintenance also in many cases fails to keep pace with traffic requirements.

It is true that driving-wheel loads are lower on electric railways, and the rotary drive from the motor eliminates the destructive hammer blow experienced from the reciprocating engines of steam locomotives. On the other hand, the low center of gravity of the ordinary electric drive often results in a high lateral pressure or bursting effect upon the rails and fastenings, especially at curves and turnouts. Where the motors are above the axles, as in some locomotives, these conditions may be modified. The advantage of shorter rigid wheel base on electric cars and locomotives is offset to some extent by the use of sharper curves on electric railways.

It has been suggested that for light roadway construction, such as is often found on interurban lines, rails of 75 to 80 lb. per yd. may be even better than those of 85 to 100 lb., owing to the greater flexibility of the former and the consequently wider distribution of the load on the roadbed and proportionately lower stress in the rail. One trouble from such flexibility, however, is that it would probably result in greater and increasing disturbance of the track substructure unless extraordinary attention was paid to maintaining the road in good condition.

One of the difficulties in the equipment of ordinary electric interurban lines is to secure large motor cars that will ride easily at high speeds. The main difficulty lies in the machinery which is carried by the car and the transmission of its power to the axles. But when such a car is propelled over track having low joints and a poor condition of surface and line, it is likely to prove an uncomfortable conveyance for passengers, which will not add to the popularity of the line. Being a motor car, it will, under these conditions, ride much more roughly than if it was simply a train car behind a steam locomotive. And while the effect of the motor car upon the track will be less destructive than that of a steam locomotive, it will be much more destructive than that of a trail car. These conditions indicate that it is highly desirable to have the track of interurban railways maintained in good condition.

On street railways of course very different conditions obtain. For the main lines in large cities the track construction is heavy in relation to the wheel loads (even where interurban cars are carried), but the amount of traffic is very great. On the other hand, track maintenance (which is daily work on open-track construction) is an impossibility, since the track is buried in the paving and can be disturbed only at long intervals. Therefore flexibility of rail and deflection of track are not permissible as on ordinary railways. For these reasons the track must be made very substantial in itself and placed on a rigid foundation, so that it will not only stand the traffic but will be free from such deflection or vibration as would disturb the paving.

It is an unfortunate fact, though, that street railways are often in the same category as other public-service corporations, both private and public, in seeming always to be hacking away at a newly completed pavement for the purpose of replacing or rearranging rails. This condition is peculiarly aggravated at crossovers and curves, mainly because wear is concentrated there.

The wear is concentrated on the railhead and at the joints, and comparatively slight wear at these parts may necessitate the renewal of heavy rails. The wear of the head is aggravated also by the dust and dirt and the grinding by wheels of cars and street vehicles. A renewable railhead for a permanent track construction in paved streets is a desirable feature that has been aimed at for many years, but has not passed the experimental stages for modern street-railway track construction. The excessive wear at special work and on the sharp curves required at street intersections is a condition that can hardly be remedied by maintenance, but here again some form of renewable wearing surface is highly to be desired.

Why Excess Condemnation Was Killed in Two States

The defeat of excess-condemnation constitutional amendments in New Jersey on Oct. 19 and in California on Oct. 26 seems to have been largely due to a lack of knowledge of what excess condemnation really is and to a state of mind which resulted in downing every amendment proposed in the two states.

The strongest real objection to excess condemnation advanced in the arguments which came to the attention of *Engineering News* in connection with these two campaigns was that the power to take more land than is actually needed for a given improvement would afford an opportunity for graft. The graft argument can always be urged until municipal conditions are vastly better than they are now, but it does not prevent material progress in other lines, and will not in this one, when the principles of excess condemnation are better understood than they are at present. More educational work is obviously needed.

The right of excess condemnation now exists, it is reported, in Massachusetts, Connecticut, New York, Maryland, Pennsylvania, Virginia and Ohio, and Wisconsin can purchase excess land at private sale, but not by condemnation. The defeats in New Jersey and California will doubtless prove to be only postponements of the adoption of a measure of public policy that is growing in support among those who understand its meaning and advantages.

Once More, the Coroner

The coroner's office has once more justified itself as the most humorous institution in New York City. Comic papers would give many dollars for just that right combination of the elusive and the absurd which marks the verdict on the first of the recent subway collapses. But why did the jury stop at the Bureau of Combustibles? Why not drag in Henry Hudson? Obviously, if he had never discovered Manhattan Island a house-that-Jack-built deduction would readily show that a new subway would never have been needed and the fatal accident of Sept. 22 would never have occurred.

Letters to the Editor

Local Sections of National Engineering Societies

Sir—In reply to the editorial query in *Engineering News* of Oct. 14 as to the effect of local sections of national engineering societies on the older type of local organizations, permit me to remark that our local society comprises 300 members, observant of the activities of chemical, electrical, mechanical and civil engineers, with proportionate benefits to the local sections and to the national bodies. In our experience the local society, embracing all kinds of engineers, is most successful.

JOHN YOUNGER,
President Buffalo Engineering Society.

Buffalo, N. Y., Oct. 22, 1915.

Information Wanted on Bureaus of Employment

Sir—It is possible that the Western Society of Engineers, 1745 Monadnock Block, Chicago, Ill., may attempt seriously the establishment of an employment bureau for the benefit of technical men and the employers of technical men.

Your active coöperation is desired. We wish to receive from officers and past officers of societies that have made similar attempts the reasons why the attempts failed, if they failed, and what degree of success was encountered. We would like to hear from every man who has any ideas on the subject, and the undersigned will not be appalled if the mails are filled with letters of advice or information. The task if properly attempted is a big one, we know, hence the desire to receive the benefit of experience and information which are certainly available.

ERNEST MCCULLOUGH,
First Vice-President, Western Society of Engineers.

Chicago, Ill., Oct. 27, 1915.

Popolopen Creek Concrete Arch Is Too Costly

Sir—It seems to me unfortunate that the competition for the design of the Popolopen Creek viaduct described in your issue of Oct. 28, 1915, p. 856, was not thrown open to more than one concrete bridge designer. I do not know what were the conditions restricting the concrete design, but assuming the ordinary principles of reinforced-concrete construction, I feel certain that a concrete arch bridge of handsome lines and sufficient strength could be built at this site for much less than the $139,000 estimated for the submitted design, which is nearly *three times as much* as the estimate for the selected steel design. Experience at similar locations has shown that while steel arches of the types submitted are cheaper than a reinforced-concrete arch, no such marked discrepancy exists between the costs of the two types.

CONCRETE ENGINEER.

New York City, Oct. 30, 1915.

More Defective Railway Track

Sir—Referring to your editorial of Oct. 21 in regard to railway-track maintenance, the part of the Interstate Commerce Commission inspector's report quoted is but a repetition of conditions which I found to exist on two different parts of one of the larger railway systems of the East—a system running trains from New York to Chicago and other points as far west as the Mississippi River. The two parts of the system I refer to are 150 mi. apart.

Both are on the main line. At one place I noticed ties cut by the rails, spikes an inch above the rail base, ties laid practically in earth and splashing mud every time a wheel went over a rail-joint. On the other part of the system the track structure is a little better, but it is in such shape that if a train would run much over 30 mi. an hour a rail would be sure to turn over. This last-mentioned piece of road is 40 mi. long and most of the grades are light; yet it takes a train from 1 hr. and 40 min. to 2 hr. to run the distance. Train crews have told me they dare not run over 30 mi. an hour on this stretch of road for fear of spilling a train.

I have not been over the road I refer to since last summer, but it is safe to say that these conditions still exist on this road. And this condition existing on a railroad that does considerable advertising to get the public to use its trains!

There should be someone with authority to see that the railroads are maintained in safe condition.

RALPH C. WOOD.

New York, N. Y., Oct. 22, 1915.

Publicity the Best Protection

Sir—The editorial on dangerous railway track in your issue of Oct. 21, 1915, p. 801, leaves the reader to infer that the only protection to the public from the dangers of such track is inspection by the government (that is to say, the Interstate Commerce Commission), and that its powers need extending. I wish to point out that there is another (and better) protection—namely, publicity.

If the newspapers publish or can publish the fact (not suspicion, but fact) that a certain railway's track is not safe, that railway will quickly be forced to make its track safe, reasonably safe—not perfect, but reasonably safe, or, say, wholly safe and reasonably good. To show that railways can and will make operations safe just for their own interest, consider the fact (and I have not seen it disputed) that the Southern Pacific Ry. killed not one passenger in a year in a train accident. This shows that conditions are not so bad on all railroads, and if they are bad on some roads, then reward the good and punish the bad. Do this by riding on the roads with good records, and not riding on the ones with bad records. This will correct the matter even though such discriminating riders are only 10% of the whole number of passengers.

That governmental regulation and inspection do not wholly prevent accidents is shown by the sinking of the steamboat "Eastland" at Chicago.

steamboat "Eastland" at Chicago. NON-SOCIALIST.

Crushed Limestone Aggregate for Concrete Pavements

Sir—I noticed in *Engineering News* of Oct. 7, 1915, the communication of G. F. Prussing, Lennon, Wis., regarding the use of crushed limestone as coarse aggregate in concrete-road construction, and it strikes me that there is some justification for the attitude taken by the highway commissioner.

I presume at the outset, although it is not so stated, that the concrete road in question is of the one-course type (without a finish coat, the surface being floated to a fairly smooth finish) which seems to be the prevailing type in Wisconsin. If such is the case, then gravel is by all means to be preferred to crushed limestone, owing to its natural ability to better withstand the abrasive forces acting on it.

Crushed limestone if made from rock taken from the main workings of a quarry may be quite hard, but in general, especially in localities (such as Lennon, Wis.) where the main product of the quarries is dimension building stone, the stone sent to the crusher is of inferior quality—strippings or chips more or less disintegrated. Such aggregate may make concrete with a compressive strength high enough to warrant its use in structures not subjected to wear or abrasion, but it should be unreservedly rejected for one-course concrete-road work.

The destructive wear and tear to which a concrete road is subjected cannot be set down in terms of stress, and owing to the great difficulties presented by that all too prevalent trouble in concrete building work, "dusting concrete floors," the profession should draw the conclusion that only the very hardest aggregate should be used in the wearing surfaces of roads, sidewalks and floors.

In 1910 the writer was connected with the design and construction of one of the first reinforced-concrete pavements, which had some unique features as regards wearing surface and expansion joints. This pavement in addition to being reinforced had a wearing course of cement and granite chips, and although subjected to heavy traffic it shows little evidence of wear and stands out in happy contrast when compared with some pavements in which limestone screenings were used in the wearing coat.

The expansion joints which were filled with "pecky cypress" are not protected by metal, but in spite of this no undue wear occurred at the joints owing to the hardness of the granolithic wearing surface.

Quite recently a concrete sidewalk adjacent to a large Chicago department store subjected to much parcel trucking has had to be repaired on account of the excessive wearing at the joints, in some cases so deep as to endanger the safety of pedestrians. The top finish of this walk was composed of limestone screenings and cement. Numerous other examples of the poor wearing qualities of some limestones could be cited.

In concrete-road work it is rather costly to treat the surface to resist abrasion, and therefore unless crushed limestone can be obtained at a very much lower price it will prove more economical in the long run to use a harder material such as gravel, crushed granite or traprock for the coarse aggregate.

Regarding the question of dust in the crushed limestone, in the writer's opinion a small amount on the stones is not objectionable, but if crusher-run stone is used too much dust and fine powder will probably be present to get the best results, using the ordinary proportions of sand and stone. In such a case more cement should be added to the mixture to fill the voids and thereby preserve the strength of the concrete. Where much limestone dust is present a thorough and longer period of mixing is essential owing to the tendency of the dust to "ball up," or form in lumps, when water is added to the batch, and unless broken up these lumps are sources of weakness in the concrete.

ALBERT M. WOLF,
Principal Assistant Engineer, Condron Co.

Chicago, Ill., Oct. 26, 1915.

Elimination of Crushing Tests for Granite Paving Blocks

Sir—I note in *Engineering News* of Oct. 21 some comment on the standard specifications for granite-block pavements recently adopted by the American Society of Municipal Improvements at its Dayton convention and on the conclusions reached as to the efficacy of the crushing test.

May I, without assuming too much of the I-told-you-so attitude, call attention to the conclusions on this subject embodied in my annual report as Chief Engineer of Highways of the Borough of Manhattan for the year 1913? The matter in it on the testing of granite paving blocks was extensively used by the Association of Granite Paving Block Manufacturers in presenting its views to the stone-block paving subcommittee of the American Society of Municipal Improvements and was largely influential in forming the determination reached, which represents a considerable change from the prevalent opinion among those discussing granite block as a paving material several years ago.

The defects in pavements referred to in the report from which you quote were the cause of the elimination from Manhattan specifications, after 1912, of gravel-filled joints.

The point to which I wish to direct attention is that all necessary studies, including a more extensive program of physical testing than has been carried out elsewhere, were made over two years ago and the standards deduced from these studies and experiments were then adopted in the Borough of Manhattan. The entire study is given with considerable detail, including all the results of these experiments in the annual reports of the Borough of Manhattan for the years 1912-1913.

The adoption of certain paving standards by the American Society for Municipal Improvements is of value to this extent, in that it rules out certain undesirable materials which will not come up to its minimum requirements. Materials which do meet its requirements can, however, be found in extensive quantities; but the success or failure of pavements laid with any granite will depend almost entirely on careful visual inspection of materials and construction.

HENRY WELLES DURHAM,
Consulting Engineer.

New York City, Oct. 28, 1915.

Sand versus Mortar Beds for Brick Pavements

By Will P. Blair*

No one can question that brick pavements constructed in accordance with the directions of the National Paving Brick Manufacturers' Association, which provide for a sand cushion immediately underlying the brick, have shown most satisfactory results. Many examples of such streets show but a slight impairment from any cause, regardless of age or traffic. The faulty ones are the direct result of a departure from or a failure to comply with the details of construction generally recognized as essential.

One of the things seldom accomplished is proper compression of the sand cushion. It is so difficult to get it done that many are willing to hazard sufficient resiliency for protection of the pavement by leaving it out altogether. It has but one function, and only one—that is, to relieve the shock due to impact in the use of the pavement and to furnish a uniform support to the overlying monolith. A requirement to fill up and roll and refill for at least three times is a necessity in order to obtain a uniform and sufficient support.

I am well aware that mortar beds under the wearing surface of pavements are neither new nor novel. Their use by past generations was not handed down to us in sufficient detail to pass judgment upon them. Our experience is therefore very limited. In recent years but few mortar beds have been tried under brick and stone pavements.

The writer has observed the behavior of five samples of brick pavements covering a period of 25 yr. In one instance the brick seemed to have been greatly injured from the shock effect. The other examples furnish evidence to the contrary.

Some 25 yr. ago a street constructed in monolithic form in Cincinnati did not prove very satisfactory. In five or six years the shock effect seemed to destroy the pavement. A small section of brick street was laid in like manner in the downtown district of Chicago, to which but little notice was given. About 18 yr. ago the brick gutters on Washington St., Indianapolis, Ind., were laid on mortar. At the same time some of the gutter on Ohio St., Terre Haute, was laid in like manner. The first two examples did not remain long in existence. The second two examples, being in gutters, scarcely afforded a condition of traffic upon which to base judgment.

The most interesting example with which the writer is acquainted is a small alley leading to a freight yard and warehouse in the rear of the Hulman & Co.'s wholesale establishment in Terre Haute. The brick were laid upon the green mortar bed of concrete made with seven parts of coarse aggregate and one part of cement. The brick surface was made smooth by the use of a rammer upon a board placed upon the pavement. The joints were then filled with 1:1 cement-grout filler, as provided in our present specifications. This pavement has been subject to frequent as well as heavy traffic for more than 10 yr. It is in almost perfect condition and shows no impairment whatever either from thermal, traffic, humidity or frost effect.

James E. Howard, Engineer-Physicist of the Interstate Commerce Commission, finds that the resiliency of well-grouted brick pavements on a sand cushion ranges between 0.0003 and 0.0100. Considering it to be a fact that no brick in such pavements have ever suffered serious injury from shock, the question naturally arises, Will injury result from shock in case the pavement slab is doubled in depth? We have in mind a monolithic structure which includes 4 in. of foundation, which structure of course will have less resiliency than the thinner slab.

It is clearly apparent that such pavements can be built with the very decided advantage of assurance that construction details are complied with. They can also be laid with the view of better resisting injury from internal strain, particularly those arising from moisture. My opinion leans toward an expectancy of good results from the monolithic construction. This opinion is strengthened by many minor points of construction aside from those mentioned.

Drainage Pumps at New Orleans

A large part of the damage resulting from the September hurricane at New Orleans was due to the breakdown of the electrically driven drainage pumps through severance of the overhead transmission lines. The first inference apt to be made from this fact is that it would have been better to have had these lines in conduits, where they would have been safe during the storm. Comment upon this is made in a recent report of the hurricane by George G. Earl, General Superintendent of the Sewerage and Water Board of New Orleans. Mr. Earl says:

Following this storm, a general and careful overhauling of the transmission lines will be necessary. The greater part of the troubles on these lines was due to the fact that telegraph, telephone and electric light and other wire lines crossed over same and fell upon them, causing short-circuits, or that trees fell across them tearing them down. The line from Central Power Station to Station 5, however, is in very soft ground and was blown over in many places, and a few poles on other lines, subjected to unusual stresses and so located that satisfactory guy wires could not be used, or where other special conditions existed, were also badly bent over.

We have often had the suggestion that underground cables would avoid line troubles of the character occasioned by this storm. To some extent they would, but the cost of an underground system is absolutely prohibitive, and underground systems, we know from experience, are also subject to troubles of other kinds, and in case of trouble in an underground system following a great storm, where the ground through which it passes is under water, the difficulty of quick location of the trouble and of its prompt repair is even greater than with an overhead system.

Pumping stations, each operated by steam, or other power at each station, is another solution which various critics of the existing system occasionally advise. I know of no other system which would have given a better service during the hurricane or remained in service longer or got back into service more promptly than the system here in use, and especially of none which can be more economically or satisfactorily operated.

*Secretary, National Paving Brick Manufacturers' Association, Cleveland, Ohio.

Choosing Air Compressors for Activated-Sludge Tanks

By Carl H. Nordell*

SYNOPSIS—Reciprocating compressors, turbo-blowers and positive-pressure blowers are considered in detail and the possibility of utilizing the fall of sewage in a shaft to compress air is briefly discussed.

Compressed air as used in the activated-sludge process of sewage treatment is required at pressures that have heretofore been met with rather infrequently. The aërating tanks are 10 to 20 or perhaps 25 ft. deep and call for pressures of 5 to 12 lb. This is debatable ground between three types of machine, so that reciprocating compressors, turbo-blowers or positive-pressure blowers may be employed. A brief discussion of the characteristics of each type will enable the formulation of a guide to the proper choice of a machine for any given set of operating conditions.

The aim of compressor manufacturers is to compress isothermally—without increase of air temperature—but that result is only imperfectly attained. For the small pressures involved in sewage aëration there are not great differences between adiabatic and isothermal working. But if the air speeds are low and the pipe runs are long, the heat of compression will be dissipated and a nearly isothermal volume will be delivered.

The reciprocating compressor is too well known to require an elaborate explanation. It can be obtained in a great variety of types, though in general it is designed to operate at higher pressures than that called for by the work in hand.

The mechanical efficiency of these compressors, as ordinarily measured by comparing the work done in the steam and air cylinders, is usually in the neighborhood of 85 to 90%. The higher the pressures it is necessary to employ the more this figure will be reduced. The older types of compressors are less efficient than the later ones. The introduction of large thin-plate valves has reduced air velocity through ports and cut down the heating at this point. The higher the pressures the hotter are the cylinder walls—even with good cooling systems—and the greater is the reduction of air taken in for compression. Tests on plants in operation show that such losses in compression may perhaps be 25% (besides the 10 or 15% mechanical losses mentioned) for the higher pressures used in aëration.

The first cost of reciprocating compressors is comparatively high, and they are bulky in proportion to their output; but they are designed in great variety, and in the larger sizes are direct-connected to steam, electric or oil-engine drive. They may be had in any capacity from less than 100 cu.ft. per min. to the large blowing engines of from 40,000 to 50,000 cu.ft. per min. High-speed single-stage machines are probably best fitted to this work.

*Engineer of Design, Sewerage Commission, Milwaukee, Wis.

The turbo-blower is a comparatively recent development. It is substantially a turbine pump. The pressure is secured by imparting a high velocity to the air, with a subsequent transformation of the velocity head into pressure head. Water weighs about 800 times as much as air; hence to secure the same pressure rise per stage with a blower as with a pump the velocity would have to be 28 times as great. In consequence the rotative speeds are usually carried as high as safety will permit. The impeller tips are sometimes run at 600 ft. per sec., when as much as 3 to 4 lb. pressure can be secured in a single stage. Ordinarily, however, 2½ lb. is considered the limiting pressure per stage.

These blowers are well adapted to handling large volumes of air. Being high-speed machines, they are compact and comparatively inexpensive for their capacity. The larger units show a very good efficiency, often reaching 75%; but the efficiency falls off with the size. Driven by direct-connected steam turbines, excellent overall economies are secured. The guaranteed steam consumption for units delivering in the neighborhood of 30,000 cu.ft. per min. is as low as 15½ lb. of steam per hour per air horsepower.

The steam-turbine-driven units have a very flexible delivery, even at constant pressure, and by slightly varying the pressure high efficiencies over a large range of deliveries can be obtained.

A complete line of turbo-blowers direct-connected to high-speed motors and delivering from 2,000 to 40,000 cu.ft. per min. has been developed. Variable delivery at constant speed over a fair range, without too great loss in efficiency, can be secured by throttling the discharge and intake.

Positive-pressure blowers operate on the same principle as a rotary pump. Lobed impellers meshing with each other in a manner similar to the teeth of a gear revolve within a casing, sweeping the air before them. The impellers do not quite touch each other or the casing, and there are consequently clearance spaces through which some of the compressed air leaks back. With well-made blowers the clearance is small and the leakage fairly low.

The amount of leakage is constant so far as the speed of the blower is concerned, but varies with the square root of the pressure. Hence these machines become less efficient as the pressure is increased, and this tends to limit their use generally to pressures below 10 lb. The leakage or slip is measured by the number of revolutions of the blower required to make it good. Thus, if the slip is 100 r.p.m. and the speed of the machine is 500, the volumetric efficiency is 400 r.p.m., or 80%. The capacity of the machine is usually stated in terms of the displacement per revolution and the delivery is equal to the displacement multiplied by the rotative speed minus the slip. Obviously the higher the speed, the better is the efficiency.

The losses other than slippage are small. Gears are used to keep the impellers in their proper relation to one another and in most machines drive one of the im-

pellers and thus transmit one half of the power. Probably 5 to 10% would cover all losses outside of slippage.

As the intake port is very large, the air is not heated on entering the blower, and thus a good volumetric efficiency is assured. Efficiencies based upon the power input range from 60 to 85%.

The positive-pressure blowers are comparatively slow-speed machines, ranging from 600 r.p.m. in the small sizes to 100 in the larger. When driven electrically they must be either belted or geared for connection with standard-speed motors. The larger sizes are well suited for direct connection to cross-compound engines, the cranks being fixed upon the impeller shaft. As the speed of these machines is suitable, they can be direct-connected to oil engines of the Diesel type.

The most important single consideration governing the choice of a machine is the volume of air it is to furnish. Probably the least volume that will be employed in practice other than testing-station work will be in the neighborhood of 1,000 cu.ft. per min., which would be ample for the treatment of 1,000,000 gal. daily in tanks 10 ft. deep. This volume at a pressure of 5 lb. could best be supplied by a positive-pressure blower because of its low first cost and good economy under these conditions.

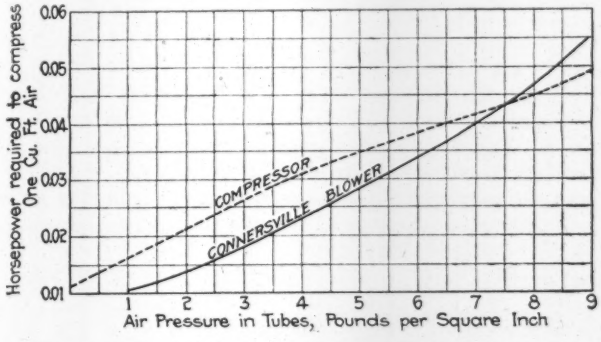


FIG. 1. POWER CONSUMED BY ROTARY AND PISTON AIR COMPRESSORS

From Thorkelson's "Air Compression and Transmission Tests" of machines of 1,500 cu.ft. per min. capacity operating the same tubes of the New York postal service.

A blower of this type and capacity should have an efficiency of 70%, and would make a dependable unit for constant service.

Where conditions favor the building of deeper tanks, so that pressures would rise above 8 or 10 lb., it might allow of the use of reciprocating compressors. Fig. 1 gives the result of tests of the respective merits of positive-pressure blowers and piston compressors; but to obtain the true relative economy of the two types there would have to be taken into consideration capital cost, depreciation and cost of attendance, all of which factors favor the positive-pressure blower.

There is another feature of the positive-pressure blower which might outweigh the smaller power consumption of the piston compressor. The most efficient air distributors so far found are porous tile. The pores of this tile are very minute and consequently may be readily clogged with foreign matter, such as heavy oil, especially if gummy and dirty. The piston compressor must of course use oil in the air cylinder, and there is some danger that it will be carried over to the tile unless it is carefully filtered out. The positive-pressure blower requires no oil in the air cylinders, as the moving parts are without contact and therefore deliver an oil-free blast at all times.

The field of the turbo-blower begins when units of 5,000 cu.ft. per min. capacity can be used. Good efficiencies can then be obtained, and the first cost will probably be about the same as that of the positive-pressure blowers, but the plant will be much more compact and perhaps somewhat lower in maintenance. The turbo-blower has the same advantages of clean blast as the positive-pressure blower.

As the volume of air required increases, the ascendancy of the turbo-blower becomes pronounced. Units of 10,000 to 20,000 cu.ft. per min. capacity are considered large in positive-pressure blowers and very large in reciprocating compressors, while turbo-blowers of more than double this capacity are not at all unusual. When the amount of air used taxes the capacity of the largest positive-pressure blowers the field is virtually clear for the turbo-blowers, as their superior economy and low first cost have then reached very favorable figures.

Considerations of pressure and volume must sometimes give way to the question of motive power. Electric power is fairly well suited to positive-pressure blowers and piston compressors in the smaller sizes, but in the larger sizes (unless expensive gearing is employed) transmission losses would begin to tell, as direct connection is not feasible. The larger sizes are especially well adapted for direct connection with reciprocating steam engines or oil engines of the Diesel type. Turbo-blowers of any capacity may be driven efficiently by direct-connected high-speed motors, and in sizes where the steam turbine is economical a direct-connected steam-driven unit is an admirable installation from every standpoint. These blowers are not suitable for direct oil-engine drive in any size, as the rotative speeds are too far apart. Therefore where oil or gas engines can be used the field of the other two types is extended considerably, as the excellent economy of the engines will offset the somewhat high cost and allow them to compete.

The type of compressor to be used depends to some extent upon whether a variable or constant delivery is required. It is by no means yet decided whether the amount of air should be increased when the peak of the sewage flow comes along or whether it should be held constant. Experiments at Milwaukee so far go to show that above a certain minimum limit the amount of air per volume of sewage can be varied within a fairly large range without deleterious effects upon the activity of the sludge, provided the general average of aëration is kept up. If it is possible therefore to run the compressor at some constant rate of delivery throughout the day, very favorable conditions are obtained for the use of positive-pressure blowers driven by constant-speed motors, especially in the smaller installations, where it is important to reduce the cost of attendance to a minimum.

But if it is found to be better practice to make the air used per volume of sewage more nearly constant, then the blast delivery must be proportional to the sewage flow. In this case the turbo-blowers will have a great advantage over the positive-pressure blowers, as even when run by constant-speed motors the delivery could be regulated very accurately, either by throttling or by increasing the working head for the periods of low flow. In the larger steam-driven plants the turbo-blowers would also have an advantage, as the delivery of the units could

be varied within wide limits, without serious loss of efficiency.

The positive-pressure blower is not well suited to a variable delivery, as the efficiency falls off with the speed and makes it the best practice to throw units in and out of service to follow the load. This necessitates splitting up the plant into a number of units and results in reduced efficiency.

The diagram, Fig. 2, gives about the economical range for the three types of blowers if the delivery is to be nearly constant, though such a diagram can naturally be only approximate.

There is another type of compressor, which has so far not been mentioned, that possesses peculiar interest in sewage-purification work—the hydraulic compressor, which has been so successfully installed in some mining districts.

This apparatus uses the weight of falling water to compress the air without the application of any intervening machinery. The water is allowed to fall through a shaft

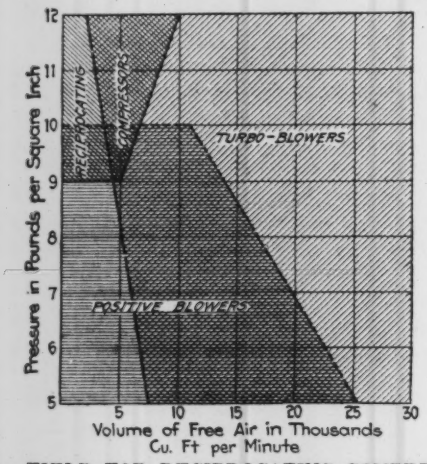


FIG. 2. FIELD FOR RECIPROCATING COMPRESSORS, TURBO-BLOWERS AND POSITIVE BLOWERS

and in doing so sucks in air through a large number of small pipes and entrains it in small bubbles, which it carries to the bottom of the shaft. After descending far enough to secure the required pressure, the mixture of air and water is allowed to flow horizontally, whereupon the air separates out and fills a reservoir, from which it is drawn as needed. Excellent results have been obtained with several installations, notably at Victoria Mine, Mich., and Cobalt, Ont. The former compresses 36,000 cu.ft. per min. to 128-lb. pressure with an efficiency as high as 82%. This remarkable showing is explained in part by the fact that the compression is absolutely isothermal, the water absorbing the heat as rapidly as it is generated.

Perhaps for the exceptional plant, where a considerable fall of sewage is available, a compressor of this type could probably be used with good results. At the same time a certain element of uncertainty exists from the possible fouling of the intake-head pipes. An inexpensive trial installation, however, would show to what degree this might be serious and how it might be obviated.

If the purification can be accomplished with ½ cu.ft. of air per gallon of sewage, as some of the Milwaukee results indicate, then an 88-ft. fall would furnish all the air required at 5-lb. pressure, if 75% efficiency could be obtained. Probably this figure would not be beyond the reach of such a compressor, even though the pressure used is somewhat low for the best results. As the cost of the activated-sludge process lies for the most part in the cost of power, it will be advisable to take advantage of any fall that would furnish even part of the air. Probably an available fall of 10 ft. could be utilized.

Experience with Engine-House Smoke Washer*

By M. D. Franey†

Extensive tests of appliances for preventing smoke led to the erection of a smokeless roundhouse in 1912 at the Englewood terminal of the New York Central lines at Chicago. This house contains 30 stalls, in which from 80 to 100 locomotives are handled each 24 hr. It is situated in a residence district and near an amusement park. Under such circumstances it was difficult for the railway company to obtain permission to build an engine house.

The locomotives west of Buffalo are equipped with two 1¼-in. blowers connected with the steam-jet smoke consumer. With ordinary care there is no excuse for smoke violation after steam has been generated, but the smoke consumer is of very little assistance in building a new fire in a cold locomotive. The handling of smoke due to firing up the engines was the problem that confronted the mechanical officers of the railway in 1910. At that time O. M. Foster, Master Mechanic, conceived the idea of forcing the smoke by means of a fan through a body of water, separating the unconsumed carbon from the gases and permitting the latter to escape through a high stack. D. R. MacBain, Superintendent of Motive Power, approved the plan, and a small plant capable of taking care of one locomotive was built at Elkhart, Ind. The results were such that a larger plant was built at Collinwood, Ohio, to take care of several locomotives, and later (1912) the Englewood plant was constructed. (Described and illustrated in *Engineering News*, May 15, 1913.)

At the Englewood roundhouse is a concrete tank 22x32 ft., partitioned into three basins. Each basin is lined with dressed lumber, set about 1½ in. from the concrete. The space between the concrete and the lining is filled with tar. Wooden pins, instead of nails, are used for fastening the lining, to resist the action of the acids. Fig. 1 is an elevation showing the general arrangement of the apparatus.

The smoke duct, 60 in. in diameter at the center and tapering to 36 in. at the ends, which extends around the house just under the roof and directly above the smoke-stacks of the locomotives, is of "Transite." Near the center of the house an elbow connects into the top of the 60-in. duct and leads down to a 70-in. steel-plate, double-inlet fan, capable of handling 68,000 cu.ft. of 500° gases per minute, at a total static pressure of 14 in. at fan outlet and at a speed of 950 r.p.m. The fan is belt-driven by a 300-hp. motor. A smoke duct leads from the fan to each of the three concrete basins, the

*Read at recent Cincinnati meeting of International Association for the Prevention of Smoke.

†Master Mechanic, Lake Shore and Michigan Southern Ry., Elkhart, Ind.

outlet to each duct coming directly under a set of three hoods whose lower ends are submerged in the tank. The smoke ducts leading from the fan, the hoods and the stack are made of wood pinned together with pegs instead of nails.

An 8-in. hole is provided in each of the partition walls to insure a uniform level of water in the three basins. An overflow pipe maintains a depth of 14 in. of water and prevents the solid matter from escaping into the sewer. A 1¼-in. high-pressure steam jet is located in each of the three ducts, close to the concrete tank, to accelerate and thoroughly mix the gases with the water and prevent them passing through the water in large bubbles.

The telescopic jacks not in use have dampers closed. A locomotive with a fire has a jack fitted to the top of its stack, with the dampers opened. In starting new fires it is necessary to use the house blower slightly, to assist the action of the fan, especially at extreme ends of the house. The carbons and solids are separated from the gases by repeated washings and rise to the top of the water in the tank in the form of a black, foamy scum. The gases pass out through the stack as a white vapor. In handling 80 locomotives per 24 hr., from 8 to 10 bbl. of carbon are obtained from the smoke washer. This has the appearance of lampblack and is thoroughly steam-dried after it is taken from the smoke washer. An analysis of this material is as follows: Moisture, 3.9%; carbon, 82.6%; sulphur, 2.6%; iron oxide, 8.7%; silica, 1.8%; calcium oxide, a trace. The sulphur and sulphuric acids are retained in the water, and the gases that pass out through the stack are practically odorless. The smoke department of the City of Chicago and the near-by residents are pleased with the results.

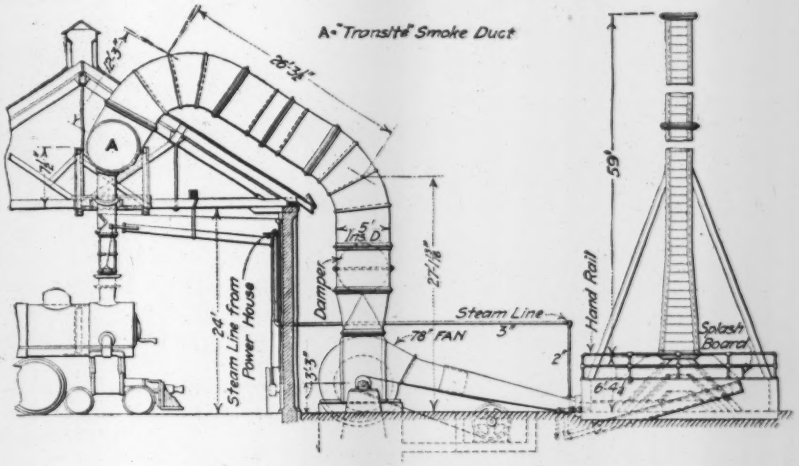


FIG. 1. ELEVATION OF LOCOMOTIVE-SMOKE WASHING PLANT, ENGLEWOOD, CHICAGO

Tank and stack at right, ducts connecting basins with fan, elbow between fan and smoke ducts, and connection between locomotive stack and duct

It is estimated that the cost of such a plant would be from $15,000 to $18,000 where the property conditions are favorable. The Englewood plant being partly experimental, its cost was somewhat greater. The cost of operation of this plant is about as follows:

Water, 18,255 gal. at 7c. per M	$1.28
Coal, 10.86 tons at $1.75 per ton	19.00
Electricity, 3,360 kw.-hr. at $0.0129	43.34
Total	$63.62

The saving from using washer, per day of 24 hr. is as follows:

Fires maintained	$40.80
New fires built	7.11
Reduced electrical cost due to sliding-scale rate	8.52
Total	$56.43

This makes the net cost of operating the washer $7.19 per day of 24 hr. It is expected that we shall be able to find a profitable use for the lampblack reclaimed.

In firing up locomotives at an ordinary engine house in a closely regulated smoke-abatement territory, it is necessary to operate the blower and smoke consumer on the engine. Their action increases the draft, which increases the coal consumption. The blower, steam jet and smoke consumer are also using a large amount of steam, which means increased consumption of water and fuel. We have found at Englewood that where the fires are properly started the draft from the fan is sufficient to draw off the gases from the locomotive without resorting to the blower. This means a decided reduction in the amount of water and fuel used.

Experience has demonstrated that the acids will eat out concrete and metals very rapidly. "Transite" (asbestos lumber) for the smoke ducts appears to be very satisfactory. A wood lining, fastened with wooden pegs and the entire surface coated with tar, has given good service where acids and water are to be resisted. This smoke washer is operated under patents controlled by the American Smoke Washing Co., S K. Dickerson, 5120 Greenwood Ave., Chicago, Ill., secretary.

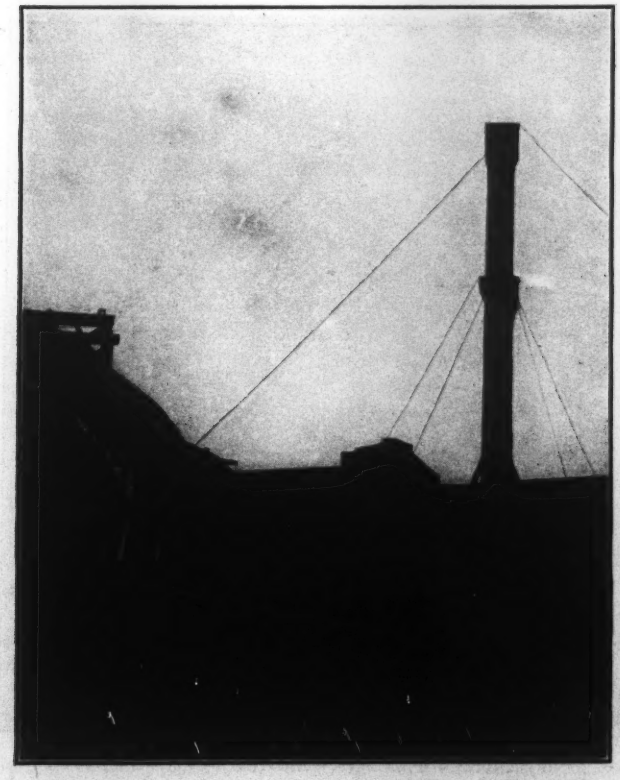


FIG. 2. EXTERIOR VIEW OF ENGLEWOOD WASHER

News of the Engineering World

Point Bridge Completed

The past month saw the completion of the North Side Point Bridge over the Allegheny River at Pittsburgh, Penn., after one of the longest construction periods on record for a bridge of its size. It takes the place of an old toll bridge, which was removed after being declared an obstruction. The chief delay in getting the new bridge was caused by failure to agree on the approaches until well after the main river spans were completed.

The total construction period was 4½ yr., as shown by the following dates:

Substructure	Started	Apr. 5, 1911
	Completed	Sept. 9, 1912
Steel spans	Started	July 23, 1912
	Completed	Nov. 5, 1913
Approaches	Started	Jan. 9, 1914
	Completed	Oct. 1, 1915

The concrete deck covering and paving were done in the period of approach construction, though let as a separate contract.

The Dravo Contracting Co., of Pittsburgh, built the substructure, the American Bridge Co. the two 531-ft. steel spans, and Booth & Flinn the approaches. The latter firm also took the paving contract. The City of Pittsburgh acted through N. S. Sprague, Superintendent, Bureau of Engineering, and T. J. Wilkerson, Division Engineer of Bridges.

Pittsburgh-Lake Erie Canal Has New Directors

Governor Brumbaugh of Pennsylvania has appointed a new Lake Erie and Ohio River canal board to replace the old board which went out of existence last May after reporting on the prospects and design of a canal to connect the Pittsburgh district with Lake Erie. The new board is composed of W. N. Stevenson, W. V. Follansbee, T. P. Sloan, David Jameson, H. C. Ogden and A. E. Adams, all bankers or "business men." The secretary of one of the associations booming the proposed canal in an interview said:

These appointees are eminently satisfactory to all the members of our association in 35 counties in western Pennsylvania, Ohio and West Virginia. I see in them a guarantee of the early construction of the great waterway. The board's first duty will be to complete the estimates of cost made by the last board, which will probably take a couple of months.

When this report has been prepared the canal association will hold a big convention in Pittsburgh of those interested in the project. This will probably be held early in January and, at it the time for holding the bond elections and the amount of money to be asked from each county will be decided. The first of these elections will probably take place next spring, and should they prove successful the canal board will probably start the actual construction of the canal next fall.

The waterway can be built in 5 or 6 yr., making allowances for legal delays, though the actual work would consume only 3 yr. The canal ought to be in operations in 1921 or 1922. At that time the Ohio River will be deepened to Cairo and with the Erie Canal open in New York we will be able to reach 27 states and Canada by water transportation.

NORTH SIDE POINT BRIDGE, PITTSBURGH, SEEN LOOKING NORTH FROM MT. WASHINGTON; SOUTH SIDE POINT BRIDGE AT LEFT

CLAY DUMP CARS, HOPPER AND WAGONS USED IN BUILDING DAMS FOR ASHBY RESERVOIR, FITCHBURG, MASS.

Coroner's Jury Finds Cause of Subway Collapse

The coroner's jury which has been investigating the collapse of the Seventh Ave. subway excavation at New York City on Sept. 22 has arrived at the following verdict:

We find that the said John W. O'Rourke came to his death on the 22d day of September in the subway excavation at 7th Ave. and 24th St. by a fracture of the skull and fractures of the ribs; that death was due primarily to an excessive blast at the northeast heading of the excavation; that, while due care was not exercised in estimating the amount of explosive to be used in this particular blast, the evidence submitted does not show criminal negligence; that the Bureau of Combustibles, Fire Department, City of New York, which has control of all blasting operations, is hereby severely censured for not carrying out, through its inspectors, the powers assigned to it by the Code of Ordinances.

We recommend that at the time of blasting in the subways of Greater New York no traffic of any kind be allowed over any part of temporary structures. We further recommend that the Public Service Commission shall designate the maximum distance to which temporary work shall precede the permanent structure. The jury, in deploring this accident, expresses the hope that it will serve to impress on all contractors and the Public Service Commission the necessity for the utmost caution and care, both in operation and inspecting of all subway work.

It is reported that the district attorney's office is investigating the accident with a view to possible criminal proceedings. This, however, completes the official inquiries into the September subway collapses. No coroner's inquest has been held as yet on the Broadway accident.

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Fitchburg Reservoir Completed Long Ahead of Time

A 700,000,000-gal. reservoir formed by two 1,200-ft. earth dams was put under construction for the City of Fitchburg, Mass., on Apr. 15, 1915, and completed Nov. 1, 1915, eight months ahead of the contract time.

The two dams are rolled earth embankments, each with a concrete heart-wall and a spillway. Quicksand at the north dam made it necessary to excavate from 30 to 36 ft. to secure a good foundation. Hardpan and boulders were encountered at the south dam.

Good embankment material was found only one-half mile distant. It was loaded into side-dump cars by steam shovels, hauled over a narrow-gage railway, dumped into hoppers, reloaded into wagons (see view) and rolled with steam rollers. Sand and boulders for crushed stone for the concrete heart-wall were found on the reservoir site. Building the heart-wall preceded and paving the upper slope followed the placing of the embankment. The top and downstream slope of each dam will be covered with top soil and seeded with grass and rye, the latter for temporary protection of the young grass. Part of the reservoir site was heavily wooded, requiring considerable cleaning and grubbing. The construction of 1½ mi. of new highway was necessary.

The reservoir was built for the Board of Water Commissioners of Fitchburg by the E. W. Foley Contracting Corporation, 71 Wall St., New York City, under the direction of Ernest E. Lothrop, City Engineer of Fitchburg, and J. D. Savage, Resident Engineer. Metcalf & Eddy, Boston, Mass., were the Construction Engineers. H. M. Clifford, of the contractors, supplied the information here given.

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Utilities Valuation Conference at Philadelphia

A tentative program has been issued by M. L. Cook, Acting Director of the Utilities Bureau, Philadelphia, for a conference on valuation of public utilities to be held in Philadelphia Nov. 10, 11 and 12. (This bureau was organized a year ago to help cities in the study of utility problems and in the adequate presentation of the municipal side of regulation cases, etc.)

All sessions will be held in the roof garden of the Adelphia Hotel. The following general topics are announced for the several sessions:

Reproduction theory, original cost, franchise values, valuing land, depreciation, going value, valuation and the future in utilities. Among the many engineers, utility commissioners and other speakers announced are: Hammond V. Hayes and Leonard Metcalf, Boston; John R. Freeman, Providence; H. P. Gillette, Milo R. Maltbie and Delos F. Wilcox, New York City; M. L. Cooke, Philadelphia; Morris Knowles, Pittsburgh; C. A. Prouty, Washington; R. H. Whelten, Newton D. Baker, Cleveland; C. E. Merriam, E. W. Bemis, Chicago; Halford Erickson, Madison, Wis.; J. E. Allison, St. Louis; Clifford Thorne, Des Moines; and John M. Eshleman, California. A full program may be obtained from M. L. Cooke, City Hall, Philadelphia.

November Election Results

Among the election issues on Nov. 2 of interest to engineers the general constitutional amendments in New York were overwhelmingly defeated, the $27,000,000 New York Barge Canal bond issue was still in doubt at time of going to press, a beginning in state ownership of sources of public water-supply in New Jersey was defeated, most of the large municipal program at Cleveland was approved, and street-railway purchases at Cleveland and at Detroit were voted down. A few particulars regarding these and some other issues follow:

The majority against the New York constitutional amendments was estimated at 375,000, on early returns. The defeat was general, regardless of party or geographical location.

Cleveland's great program of city improvements came through successfully for the major part. All the railway projects were carried, but the proposal to purchase the street railways was defeated. Specifically the voting resulted as follows: *Carried*: Union Station proposal, clearing the way for immediate construction of the new Lake Shore station; Cleveland & Youngstown R.R. franchise, for a freight terminal and downtown passenger station; Cleveland, Akron & Canton Terminal Ry. franchise, for East 55th St. subway; bond issue $1,600,000 for city's share in grade-crossing abolition; bond issue $1,000,000 for new schools; $2,000,000 to carry on sewage-disposal construction already under way; charter amendment fixing minimum daily wage of $2.50 on municipal work. *Defeated*: Proposal that city purchase the street-railway property from the Cleveland Ry. Co.; bond issue $100,000 for public-comfort stations; bond issue $300,000 for opening up Carnegie Ave. extension; bond issue $1,500,000 for deficiencies.

Municipal purchase of the privately owned Detroit United Railway was voted down. Of the total vote of 68,231 only 32,628 voted for purchase, or 8,278 less than the three-fifths needed to carry the proposition. The purchase has long been a local issue and the campaign was a bitter one.

New Jersey voted against a $1,000,000 bond issue to enable the State Water-Supply Commission to buy the "Wharton tract" in South Jersey for use in developing an underground water-supply. This tract was originally acquired by a promoter of one of the many schemes to supply water to Philadelphia before that city finally decided to filter water from the Schuylkill and Delaware rivers.

Commission government was voted on in a number of cities. Salem, Mass., under a system peculiar to the Bay State, having tried the commission plan for two years, voted on its continuance as against a change. The vote stood 3,122 to 2,677 for changing to a mayor and 11 aldermen, the mayor to have large if not absolute veto power. The commission plan was adopted in Bridgeport, Conn., and Watertown, N. Y., while Buffalo, Newburg and Niagara Falls, N. Y., elected commissioners for the first time under the commission plan. A city manager will be chosen by the Niagara Falls Commission; also by a commission at Ashtabula, Ohio, the latter elected under the Hare proportional representation plan.

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A Butting Collision on Oct. 19 between a passenger train and a freight train on the Chicago, Rock Island & Pacific Ry. at Agawam, Okla., caused the death of seven persons and probably fatal injuries to two or three others.

Over 2,500 Lin.Ft. of Snowsheds on the Southern Pacific R.R., at Summit, Calif., were destroyed by fire on Oct. 17. The Summit railroad station, a reinforced-concrete structure, was slightly damaged. Through trains were delayed several hours while temporary tracks were laid around the burning sheds.

A Small Grain Elevator Tilted by rotting or settlement of its timber suports on one side, at Starbuck, Man., Canada, on Oct. 22, 1915. The first signs of yielding were noticed 4 or 5 hr. before the building fell off its foundation and came to bearing on the ground several feet to one side of its original position and out of plumb.

An Earth Slide on the Panama R.R., about 2 mi. north of Pedro Miguel, on Oct. 31, temporarily buried about 200 ft. of track and closed the road to traffic during one of its most congested periods. The slide is supposed to have been caused by unusually heavy rains and is particularly unfortunate at this time when the canal is closed to all traffic.

A Fire in a Brick School Building at Peabody, Mass., on Oct. 23 resulted in the death of 21 children. There were 600 children in the school when the fire was discovered. It is stated that every requirement of the law in the way of building construction and fire protection had been complied with and that the loss of life was caused "by the unfortunate place in which the fire started under the main stairway and to the accidental blocking of the main exit." The building was of brick exterior, with wood floors and partitions, and the fire is said to have swept through the three stories in 5 min. There were no fire escapes on the building.

The Scranton-Hallstead Cut-off of the Delaware, Lackawanna & Western R.R. will be opened for passenger traffic on Nov. 7. This line revision, described in "Engineering News," of Aug. 29, 1913, p. 410, is a relocation between Clarks Summit, 7 mi. west of Scranton, and Hallstead, 41 mi. farther west, at the summit of the division. While reducing the mileage only 3 mi., the betterment of line and grade is most marked. Construction was very heavy, particularly in cut and fill and in the erection of the two record-breaking concrete bridges at Tunkhannock and Martin's Creek.

PERSONALS

Mr. R. H. Pinkham, Assistant Supervisor of the Pennsylvania R.R. at Derry, Penn., has been promoted to be Division Engineer of the Renovo division.

Mr. J. K. Sherman, Assistant Engineer of the Pittsburgh division of the Pennsylvania R.R., has been promoted to be Division Engineer of the Zanesville division.

Mr. J. F. Twamley has been elected Second Vice-President and a Member of the Board of the Bath Portland Cement Co. His headquarters will be at 1182 Broadway, New York City.

Mr. V. D. Allen, Building Commissioner of the City of Cleveland, Ohio, has tendered his resignation, to take effect Jan. 1, 1916. Mr. Allen, it is stated, will go into private business.

Mr. Arthur Hastings, recently connected with the Franklin Steel Works, Franklin, Penn., has entered the employ of the Turner Construction Co. as Assistant Engineer in the company's Buffalo, N. Y., office.

Mr. R. G. Jones, Assistant Engineer of the Northern division of the Grand Rapids & Indiana Ry. at Grand Rapids, Iowa, has been promoted to be Division Engineer of the Southern division at Fort Wayne, Ind.

Mr. James Cole Roberts, M. Am. Inst. M. E., of the United States Bureau of Mines, Denver, Colo., has been elected to the Joseph Austin Holmes Professorship of Safety and Efficiency Engineering at the Colorado State School of Mines, Golden, Colo.

Mr. D. W. Cole, M. Am. Soc. C. E., Project Manager of the United States Reclamation Service, Fallon, Nev., has been granted leave of absence—the first in six years. A recent report in another publication, that Mr. Cole has resigned, was in error.

Dr. Charles P. Steinmetz, Past President of the American Institute of Electrical Engineers and Chief Consulting Engineer of the General Electric Co., has been elected President of the Common Council of the City of Schenectady, N. Y., on the Socialist ticket.

Mr. F. C. French, M. Am. Soc. C. E., formerly Designing Engineer of the Anaconda Copper Mining Co., Anaconda, Mont., has become Construction Engineer on the remodeling and enlargement of the plant of the Beaston Copper Co. at Latouche, Alaska.

Mr. William Goldsmith, Assoc. M. Am. Soc. C. E., has resigned as Superintendent of the municipal asphalt plant of the Borough of Manhattan, New York City, to accept a position as Engineer in Charge of Construction of the New Hampton Farms Reformatory.

Mr. Malcolm Lewis, at present connected with the Lederle Laboratories, New York City, and a graduate of the Massachusetts Institute of Technology, has been appointed Sanitary Inspector of the Montclair, N. J., Board of Health, to succeed Lewis O. Taynton, who recently resigned. Last year Mr. Lewis was an assistant instructor in biology at Rutgers College.

Mr. L. E. Yost, formerly Superintendent of the openhearth and blooming-mill departments of the Upson Nut Co., Cleveland, Ohio, has been appointed to a similar position at the new plant of Corrigan, McKinney & Co., of the same city. He will be succeeded by Mr. R. B. Bostwick, Superintendent of openhearth department No. 3 of the Homestead, Penn., works of the Carnegie Steel Co.

Mr. Luciana Selmi, formerly Chief Chemist and Metallurgist of the Otis Steel Co., has become associated with Corrigan, McKinney & Co., Cleveland, Ohio, in charge of the new chemical and physical laboratories being built at the company's plant in connection with the construction of additional steel mills. He is succeeded at the Otis plant by Mr. Frank B. Poto, recently connected with the Youngstown, Ohio, Sheet and Tube Co. and formerly for ten years Chief Chemist of the Buckeye Steel Co., Columbus, Ohio.

Mr. Edward M. Boggs, M. Am. Soc. C. E., Chief Engineer of Docks and Wharves of the San Francisco and Oakland, Calif., Terminal railways, has been appointed Chief Engineer of the Department of Way and Structures, with headquarters at the General Office Building of the company. Mr. Boggs succeeds Mr. George H. Binkley, M. Am. Soc. C. E. Mr. A. W. Macpherson has been appointed Assistant Chief Engineer with the same headquarters. The departments known as the Maintenance-of-Way and Structures and Docks and Wharves have been consolidated and will hereafter be known as the Department of Way and Structures.

Mr. Henry Latimer Collier, for several years past Consulting Engineer of the Yellow Pine Manufacturers' Association at St. Louis, Mo., has opened an office as a consulting and constructing engineer in the Candler Building, Atlanta, Ga. Mr. Collier was graduated from the University of Georgia in 1872. For 10 yr. he served as Commissioner of Public Works of Atlanta and for five years was connected with the United States Department of the Interior as a member of the College of Examiners of Surveys. He will specialize in street and highway pavements and reinforced-concrete construction and the location of disputed land lines and boundaries.

Mr. Louis K. Rourke, M. Am. Soc. C. E., recently Commissioner of Public Works of Boston and formerly Assistant Division Engineer of the Central Division of the Panama Canal, and Mr. Edward C. Sherman, M. Am. Soc. C. E., Consulting Engineer, formerly Division Engineer on the Charles River Dam and Lock at Boston and later Designing Engineer on the Panama Canal, have formed a partnership under the firm name of Rourke & Sherman, with offices at 6 Beacon St., Boston, Mass. They will specialize in the organization, design, construction and operation of public works, including river and harbor improvements, refuse disposal, water-supply, sewerage and pavements, railroad work, and on Spanish-American projects.

OBITUARY

Zenas N. Vaughn, a civil engineer well known in Idaho through his connection with much of the irrigation development in that state, died recently at his home in Boise from injuries received in a runaway accident on a mountain road. Mr. Vaughn was recently engaged in the construction of the Crane Creek Irrigation, Land and Power Co.'s system near Weiser, Idaho.

Thomas Francis Cheyney, a young mining engineer, a graduate of the Case School of Applied Science, disappeared on Aug. 23 from a mining camp where he was employed in the Cobalt silver mining district. No trace was found of him until a few days ago, when his brother, Carl A. Cheyney, of Cleveland, received word that the body had been found on a lonely trail in the Cobalt region, although no details as to the manner of his death were given in the message. Mr. Cheyney was 28 years of age.

Olaf Ridley Pihl, M. Am. Soc. C. E., senior member of the engineering firm of Pihl & Miller, of Pittsburgh, Penn., died suddenly from heart disease on Oct. 14, at the Allegheny General Hospital. He was born in Norway and came to the United States in 1880. Ten years later he became associated with the late William H. Kennedy, M. Am. Soc. C. E., in the Oregon Railroad and Navigation Co., at Portland, Ore., serving there and later at Buffalo, N. Y., as United States Assistant Engineer. He was connected with the Pan-American Exposition, and in 1902 went to Pittsburgh.

ENGINEERING SOCIETIES

COMING MEETINGS

THIRD ANNUAL PENNSYLVANIA WELFARE AND EFFICIENCY CONFERENCE.
Nov. 16-19. Conference in Philadelphia.

NATIONAL MUNICIPAL LEAGUE.
Nov. 17-19. Annual convention, Dayton, Ohio. Secretary, Clinton Rogers Woodruff, 705 North American Building, Philadelphia.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS.
Nov. 18-19. Annual meeting at Zanesville, Ohio. Secretary, F. E. Sanborn, Columbus, Ohio.

AMERICAN INSTITUTE OF ARCHITECTS.
Dec. 1-3. Annual convention in Washington, D. C. Executive Secretary, E. C. Kempe, The Octagon, Washington.

AMERICAN ASSOCIATION OF ENGINEERS.
Dec. 10 and 11. Convention in Chicago. Secretary, Arthur Kneisel, 29 South La Salle St., Chicago.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.
Dec. 13-15. Annual meeting in New York. Secretary, Percy H. Wilson, Bellevue Court Bldg., Philadelphia, Penn.

SECOND PAN-AMERICAN SCIENTIFIC CONGRESS.
Dec. 27-Jan. 8. Washington, D. C.

American Highway Association—The following officers have been nominated for 1916: President, Fairfax Harrison; vice-president, Logan Waller Page; treasurer, Hon. John Burke; directors, W. T. Beatty, George W. Cooley, Clarence A. Kenyon, James H. MacDonald, E. J. Mehren, Dr. Joseph Hyde Pratt and Henry G. Shirley.

American Road Builders' Association—At a meeting of the directors of the association held in New York City, Oct. 22, it was unanimously resolved not to participate in a proposed International Road Congress to be held in Worcester, Mass., Dec. 14 to 17, 1915. It was also unanimously voted at this meeting to hold the next convention and exhibition during the month of either January or February next, the exact time and place to be left to the executive committee. It is expected that a decision will be reached within the next few days. Cleveland, Ohio and Pittsburgh, Penn., are the two cities whose relative facilities are now being considered by the committee. The decision to hold the annual good-roads show in connection with the convention was made owing to what seems to be a very general demand for it from manufacturers.

Third Pennsylvania Welfare, Efficiency and Engineering Conference—The conference this year, Nov. 16-19, will be of greater scope than those of the preceding years. Among the men who will preside are Dr. John Price Jackson, Commissioner of Labor and Industry; Robert J. Cunningham, State Highway Commissioner; Dr. F. Herbert Snow, Chief, Bureau of Engineering, Public Service Commission, and Farley Gannett, President, Engineers' Society of Pennsylvania. The program includes many subjects of general interest, such as city planning, fire prevention, water-supply, highways and many subjects related to state and municipal government. Coincident with the meeting of the conference the exhibit, which is under the management of the Engineers' Society of Pennsylvania, in conjunction with the officials of the conference, will be held at the car barns of the Harrisburg Railways Co., the use of which has been donated for this purpose.

Appliances and Materials

Bulb Angles and Beams Now Rolled

Years ago the use of bulb angles and bulb beams was quite extensive in shipbuilding construction, and steelmakers of the United States rolled a limited line of both sections such as experience had found suitable. There then followed a tendency in shipbuilding to utilize steel channels in the place of the bulb sections, and for many years the tonnage rolled was extremely limited. Recently, however, the tide has turned again in favor of the bulb-angle and bulb-beam type of construction. In addition, the bulb-angle section has now come into use for strengthening the tops of all steel gondola freight

cars and a number of sizes particularly designed for that purpose have come into use. Through the revival in American shipbuilding due to the European War a number of vessels are now under construction to English standards in which the bulb angle is used in floor framing.

The Carnegie Steel Co., of Pittsburgh, now rolls for the first time in this country a fairly complete line of bulb angles to British standards. Orders are being executed as promptly as mill conditions warrant. The company has issued a pamphlet entitled "Bulb Sections," containing tables and data on all profiles now being rolled.

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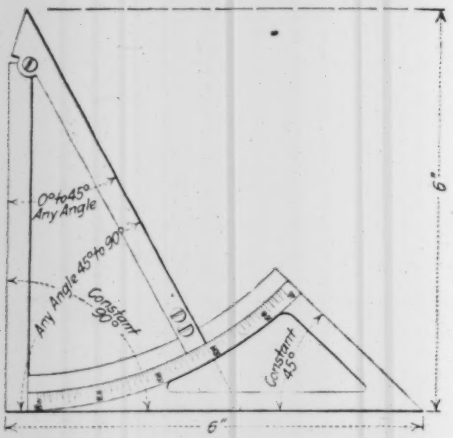
Universal-Angle Drafting Triangle

A triangle with which lines can be drawn inclined at any angle is now being made by L. F. Hellman, of Indianapolis, Ind. (Box 269, R.R. 26). The design is shown in the accompanying sketch. The device is made of cast aluminum, $\frac{3}{16}$ in.



HELLMAN'S UNIVERSAL TRIANGLE

thick, and is smooth on both sides. The base and one side are rigid, but a part of the hypothenuse swings about a friction point. The arc is graduated to half degrees, but quarter degrees can be estimated. Triangles graduated for slope and pitch are also supplied. Only the 6-in. size is made, and this sells for $2.

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Locking Bell-and-Spigot Pipe Joint

Cast-iron pipe has continued to be favored for waste-, vent- and soil-pipe lines on account of reported unfavorable experience with wrought iron and steel. But with the advent of high buildings in cities trouble has developed in the long lines of waste pipes, which are subjected to heavy stress due to sudden and large changes in temperature caused by alternate flushing with hot and cold water. This has loosened the leaded bell-and-spigot joints so that sewer gases have

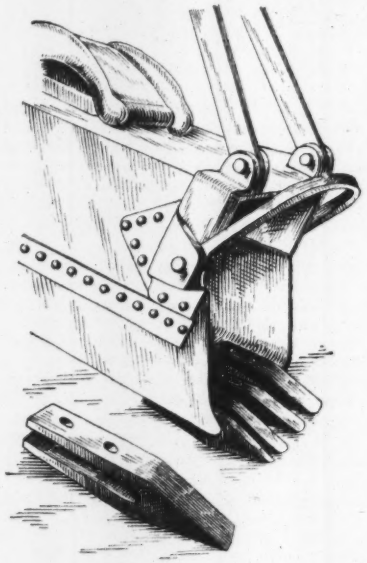
LOCKING BELL-AND-SPIGOT PIPE JOINT

escaped. To meet the need of a locked bell-and-spigot joint the Central Foundry Co., of New York City, has developed the design shown in the accompanying sketch.

The bell end has four helical interior ribs near the inner shoulder. The spigot end has four exterior helical ribs. The spigot is inserted in the bell and given a quarter turn; then oakum is tamped in and the lead poured and calked as usual. There is a groove inside the bell to hold the lead. When it is necessary to cut this pipe to measure on the job, a malleable-iron end ring replaces the spigot end which has been cut off. The pipe is cast so that it engages with the malleable ring. Several lengths of this soil pipe can be jointed on supports and will not sag when the intermediate supports are taken away. If the middle is loaded to collapse, the pipe breaks beyond the joint. Soil pipe in 2- to 6-in. sizes is now made with this joint. The cost is about the same as for the ordinary type.

Easy-Loading Dipper Tooth

An easy-loading style of one-piece tooth for steam-shovel and dredge buckets has been designed and is being manufactured by George P. Chambers, 110 North Madison Ave., La Grange, Ill. The device is shown in the accompanying sketch. The tooth is made in carbon steel for resharp-



CHAMBERS' REVERSIBLE DIPPER TOOTH

ening or manganese steel for especially severe service. The teeth are reversible, so that when worn on one side they may be turned over and reused. It is claimed that a bucket equipped with these teeth loads more material than with any standard tooth, and that particular benefit has been shown in picking up large stones on level ground. These teeth are used at the Dolese and Shepard quarries at Gary, Ill., and by the Brownell Improvement Co., Thornton, Ill.

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Six-Wheel Motor Truck

A six-wheel motor truck, resembling a tractor-trailer outfit, has been designed by the Chicago Pneumatic Tool Co., of Chicago. It is aimed to transfer to the tractor drive wheels only enough load to give the traction necessary for pulling

SIX-WHEEL MOTOR TRUCK

the capacity of the body. A ball race is interposed between tractor and trailer sections. A special connection between the rear-axle supports and the driving truck makes the rear wheels track with the forward wheels. The machine is claimed to turn in a 36-ft. space, even when loaded with 40-ft. lumber.

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Universal Concrete-Culvert Form

A galvanized-steel culvert-form outfit for all sizes and styles, from 15-in. to 6-ft. span, with flat or arched tops, is being made by the Concrete Form Co., of Syracuse, N. Y. This equipment is sold under the trade name of "Whalen Form." It consists of four arch-top sections, 24 in. wide, 27 in. high and 24 ft. long. For culverts wider than 24 in. two lengths are placed parallel and spanned with cover plates. The outfit comprises also two 48x84-in. head-wall forms, one set for wing walls, one parapet box and six 2x3-ft. cover plates.